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MANUAL OF ANATOMY

SYSTEMATIC AND PRACTICAL, INCLUDING EMBRYOLOGY

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MANUAL OF ANATOMY

SYSTEMATIC AND PRACTICAL, INCLUDING EMBRYOLOGY

BY

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VOL. II.

ABDOMEN; THORAX; HEAD AND NECK; NERVOUS SYSTEM; ORGANS OF SPECIAL SENSE; AND AN APPENDIX CONTAINING THE BÂLE NOMENCLATURE AND A GLOSSARY

WITH 363 ILLUSTRATIONS, MOSTLY ORIGINAL AND IN COLOURS

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DELETION.

On p. 1239, line 21 from top, delete **Conducting.**

ERRATA.

On p. 783, line 2 from bottom, instead of ' for ' read ' far.'
On p. 838, line 25 from top, for *muliebris* read *muliebres.*
On p. 1282, line 10 from top, for ' upwrds ' read ' upwards.'

OMISSIONS.

On p. 657, line 18 from bottom, and line 7 from bottom, after the words ' left border of the sternum ' read ' and about 1 inch below the left nipple.'

On p. 1302, line 6 from top, read as follows:

Rhinencephalon.—The rhinencephalon, or olfactory brain, of feeble development comparatively in man, may be regarded as consisting of the following closely-associated parts: The olfactory lobe, the uncus (which represents the lobus hippocampi or lobus pyriformis, so well developed in many mammals), the gyrus dentatus, the supracallosal gyrus, the subcallosal gyrus, one lamina of the septum lucidum, one half of the fornix, and the hippocampus major.

A MANUAL OF ANATOMY

THE ABDOMEN

MALE PERINEUM.

Landmarks.—The tuber ischii can be felt on either side, as well as the ischio-pubic ramus; but the great sacro-sciatic ligament cannot be felt, on account of the thickness of the lower border of the gluteus maximus. The tip of the coccyx is very accessible to the finger.

The perineum practically corresponds with the outlet of the pelvis, and is somewhat lozenge-shaped, having the subpubic angle in front, the tip of the coccyx behind, and the tuber ischii on either side. It is conveniently divided into two parts by a line connecting the ischial tuberosities, each division being triangular. The anterior represents the uro-genital or urethral division, this being the perineum proper, and the posterior the ischio-rectal or anal division. The skin of the uro-genital division presents an antero-posterior median elevation, called the perineal raphé, which extends over the posterior and anterior surfaces of the scrotum, and along the under surface of the penis. The position of the deeply-placed central tendinous point of the perineum is indicated by taking a point in this raphé very nearly 1 inch in front of the anus.

The **anus** is the external opening of the anal canal. It is situated posterior to a line connecting the front parts of the ischial tuberosities, and about 1½ inches from the tip of the coccyx. A delicate white line surrounds the anus where the skin and mucous membrane meet, which indicates the separation between the external and internal sphincter muscles (Hilton). The position of each ischio-rectal fossa is indicated by a slight depression between the anus and tuber ischii.

Deep Boundaries of the Perineum—*Anterior.*—The subpubic angle and subpubic ligament. *Posterior.*—The coccyx. *Lateral.*—From behind forwards, the inferior border of the great sacro-sciatic ligament, tuber ischii, and ischio-pubic ramus.

Ischio-Rectal Division.

Cutaneous Nerves.—These are (1) the **hemorrhoidal** or **perineal branch** of the lower part of the anterior primary division of the

fourth sacral, and (2) the **inferior hemorrhoidal nerve**, which is a branch of the pudic. The former supplies the integument between the tip of the coccyx and the back of the anus, and the latter the integument between the anus and tuber ischii.

Fascia.—The fascia of this division is very thick, and is prolonged into the ischio-rectal fossa, where it forms an elastic pad for the lower part of the rectum and the anal canal. There is no deep fascia.

Ano-coccygeal Body.—This is a collection of fibrous and muscular tissues situated between the coccyx and anal canal, the muscular element being connected with the levatores ani and sphincter ani muscles (Symington). Its importance lies in the fact that it gives support to the anal canal.

Muscles.—The muscles in this division are the sphincter ani externus, corrugator cutis ani, levator ani, and coccygeus.

Sphincter Ani Externus—*Origin.*—The tip of the coccyx and the integument over it.

Insertion.—The greater part of the muscle is inserted into the central tendinous point of the perineum. The more superficial fibres, however, are inserted into the skin, and a certain amount of decussation takes place across the middle line.

Nerve-supply.—The part of the muscle between the coccyx and the anus is supplied by the hemorrhoidal or perineal branch of the fourth sacral, and the remainder by the inferior hemorrhoidal and the deep branch of the perineal nerve, both of which are derived from the pudic.

Action.—To keep the anal aperture closed, at the same time producing a wrinkled condition of the skin.

The muscle is situated immediately beneath the skin, and is elliptical. Behind and in front of the anus it is single, but around that aperture it is arranged in two symmetrical halves, which are intimately connected with the middle portions of the levatores ani.

Corrugator Cutis Ani (Ellis).—This muscle is represented by a very delicate sheet of involuntary muscular fibres, which pass in a radiating manner from the submucous tissue of the anal aperture to be inserted into the surrounding skin.

Action.—(1) To throw the integument around the anus into wrinkles; and (2) to invert the mucous membrane of the lower end of the anal canal after it has been everted during defæcation.

For the **levator ani** and **coccygeus**, see pp. 807 and 808.

Ischio-rectal Fossa.—This is a deep fossa which is situated on either side between the ischium and rectum. It measures nearly 2½ inches in depth, 2 inches from before backwards, and 1 inch from side to side. In transverse section it is triangular, the base being directed downwards and the apex upwards. The **outer wall,** which is vertical, is formed by the lower part of the obturator internus muscle covered by the obturator fascia. The **inner wall,** which is oblique and longer than the outer, is formed by the lower part of the rectum, the anal canal, the levator ani muscle covered by the anal fascia, and the sphincter ani externus. The **base** is

formed by the skin and fascia which extend between the tuber ischii and anus. The **apex** is just below the *white line*, where the anal fascia springs from the obturator fascia. *Anteriorly* the fossa is partially limited by the reflection of the fascia of Colles round the posterior border of the superficial transverse perineal muscle to join the base of the triangular ligament of the urethra. Above this junction there is a forward prolongation of the fossa, called the *anterior diverticulum*, which extends almost to the symphysis pubis. It lies between the postero-superior layer of the triangular ligament and the inferior surface of the anterior part of the levator ani muscle,

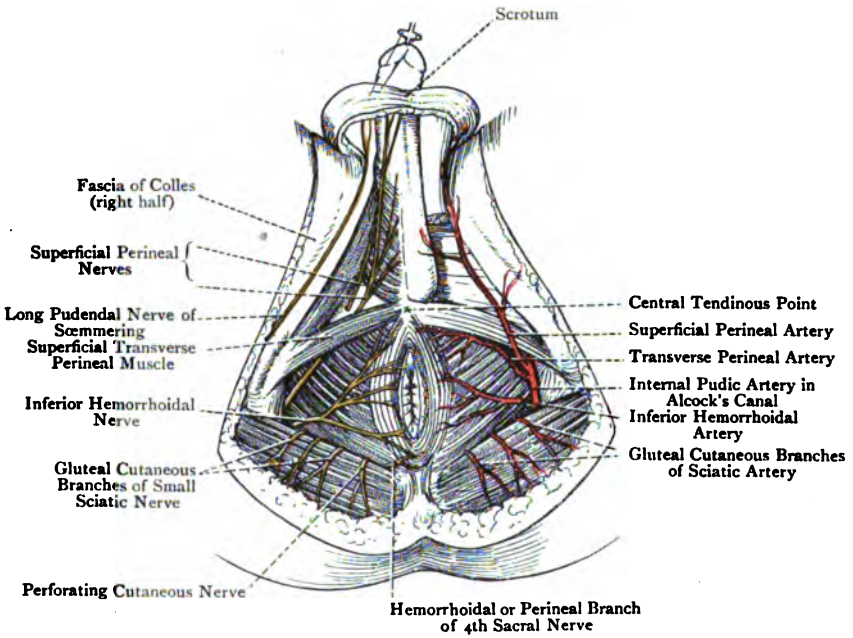

Scrotum
Fascia of Colles (right half)
Superficial Perineal Nerves
Long Pudendal Nerve of Scemmering
Superficial Transverse Perineal Muscle
Inferior Hemorrhoidal Nerve
Gluteal Cutaneous Branches of Small Sciatic Nerve
Perforating Cutaneous Nerve
Central Tendinous Point
Superficial Perineal Artery
Transverse Perineal Artery
Internal Pudic Artery in Alcock's Canal
Inferior Hemorrhoidal Artery
Gluteal Cutaneous Branches of Sciatic Artery
Hemorrhoidal or Perineal Branch of 4th Sacral Nerve

FIG. 267—DISSECTION OF THE MALE PERINEUM

(On the left side the bulbo-cavernosus has been removed, and the crus penis cut).

and its lateral limits are the prostate gland and pubo-prostatic ligament internally, and the ischio-pubic ramus externally. *Posteriorly* the fossa is partially limited by the margin of the great sacro-sciatic ligament and the lower border of the gluteus maximus muscle. Between these two structures it is prolonged backwards for a short distance in the form of a *posterior diverticulum*, which extends outwards towards the tuber ischii, and inwards towards the upper part of the coccyx.

Position of Contents.—The internal pudic vessels and the perineal and dorsalis penis branches of the pudic nerve lie upon the outer

wall about 1½ inches above the lower part of the tuber ischii, and they are contained in Alcock's canal. The inferior hemorrhoidal vessels and nerve cross the fossa transversely from the outer wall to the anal canal. The superficial perineal vessels and nerves on their way forwards lie for a short distance in the front part. At the back part of the fossa, winding round the lower border of the gluteus maximus, the gluteal cutaneous branches of the small sciatic nerve and sciatic artery, as well as the perforating cutaneous branch of the sacral plexus, are met with.

The fossa is filled with loose fat, which also extends into the anterior and posterior diverticula.

This fat is badly supplied with bloodvessels, and its vitality is therefore low. As a consequence, an ischio-rectal abscess is of not infrequent occurrence. When an abscess forms, the pus has a tendency to discharge itself in two directions, namely, through the skin forming the floor of the fossa, and through the wall of the anal canal about half an inch above the anus. When this happens a complete *fistula in ano* is the result.

The severe pain which accompanies an ischio-rectal abscess is due to pressure upon the following nerves: (1) the inferior hemorrhoidal; (2) the two superficial perineal nerves; and (3) the gluteal cutaneous branches of the small sciatic.

Uro-Genital Division.

Superficial Fascia.—The superficial fascia resembles that over the lower part of the anterior wall of the abdomen in being divisible into two layers, which are called the subcutaneous layer and the deep layer or fascia of Colles.

The **subcutaneous layer** is fatty and granular. When followed backwards on either side it forms the floor of the ischio-rectal fossa. At the middle line it is continuous with the corresponding layer of the opposite side. Externally it passes freely over the ischio-pubic ramus, and is continuous with the superficial fascia of the inner side of the thigh. Anteriorly it passes into the scrotum, where it joins the deep layer or fascia of Colles. The resultant fascia, now free from adipose tissue, contains involuntary muscular tissue, and forms the tunica dartos. The subcutaneous layer represents the fascia of Camper of the lower part of the anterior abdominal wall.

The **deep layer** constitutes the **fascia of Colles.** It is membranous and strong. *Externally*, it is attached to the anterior everted lip of the inner border of the ischio-pubic ramus, as far back as the tuber ischii, immediately outside the attachment of the crus penis. *Internally*, the fascia of one side is continuous with that of the other along the middle line. *Posteriorly*, the fascia turns round the posterior border of each superficial transverse perineal muscle, and joins the base of the triangular ligament. *Anteriorly*, it passes into the scrotum, where it joins the subcutaneous layer, the two forming the tunica dartos.

The fascia of Colles represents the fascia of Scarpa of the anterior abdominal wall. It encloses a space over the anterior division of the perineum, called the **perineal pouch.** This pouch is partially

subdivided into two compartments by an incomplete septum, which extends upwards from the deep or superior surface of the fascia of Colles to be attached to the median raphé above. This septum is only complete for a short distance at the back part; elsewhere it is very imperfect, and is continued forwards into the scrotum.

When air is blown beneath the back part of the fascia of Colles on one side of the middle line, the fascia of that side and the corresponding half of the scrotum become distended. As more air is blown in, the fascia of the opposite side and the corresponding half of the scrotum also become distended.

It is into the perineal pouch that urine is extravasated in rupture of the urethra in the perineum. In such cases the urine cannot pass into either ischio-rectal fossa, its backward course being arrested at the posterior borders of the superficial transverse perineal muscles, where the fascia of Colles, as a whole, turns round to join the base of the triangular ligament. Neither can the urine make its way down the inner side of the thigh, its passage in this direction being stopped at the ischio-pubic ramus to which the fascia of Colles is attached. The only course, therefore, which is impressed upon the extravasated urine is forwards into the scrotal wall and on to the penis, in each case beneath the dartos tunic, whence it passes upwards along the spermatic cord to the anterior wall of the abdomen, in which situation it lies beneath the fascia of Scarpa.

The fascia of Colles covers the following structures: the crura penis, covered by the ischio-cavernosi muscles; the bulb of the urethra, covered by the bulbo-cavernosi muscles; the superficial transverse perineal muscles; the superficial perineal vessels of each side; the three long scrotal nerves of each side; and the deep perineal triangle of each side, in the area of which is one half of the antero-inferior layer of the triangular ligament.

Muscles—Transversus Perinæi Superficialis—*Origin.*—The inner aspect of the tuber ischii above the origin of the ischio-cavernosus.

Insertion.—The central tendinous point of the perineum.

Nerve-supply.—The deep division of the perineal branch of the pudic nerve.

Action.—To draw back and fix the central tendinous point, and so to aid the action of the bulbo-cavernosus.

The muscle is directed obliquely inwards and forwards, being accompanied by the transverse perineal artery, and it forms the base of the deep perineal triangle.

Ischio-cavernosus (erector penis)—*Origin.*—(1) The inner aspect of the tuber ischii close below the origin of the superficial transverse perineal muscle; and (2) the inner border of the ramus of the ischium on either side of the crus penis.

Insertion.—The under surface of the fibrous sheath of the crus penis in its front part, and the outer and upper surfaces of the fibrous sheath of the corpus cavernosum penis, in which latter situation it is continuous with the fascial investment of the penis and with the insertion of the suspensory ligament of that organ.

Nerve-supply.—The deep division of the perineal branch of the pudic nerve.

Action.—The muscle compresses the crus penis against the ischio-pubic ramus, and, by retarding the return of venous blood, it helps to maintain the penis in a state of erection. It also contributes to the maintenance of erection by compressing the dorsalis penis vein.

The anterior and outer part of the muscle is sometimes detached, and forms a separate muscle, called the **compressor venæ dorsalis penis.** This arises from the descending pubic ramus, anterior to the origin of the ischio-cavernosus, and it terminates in an aponeurotic expansion which joins its fellow of the opposite side over the dorsal vein of the penis.

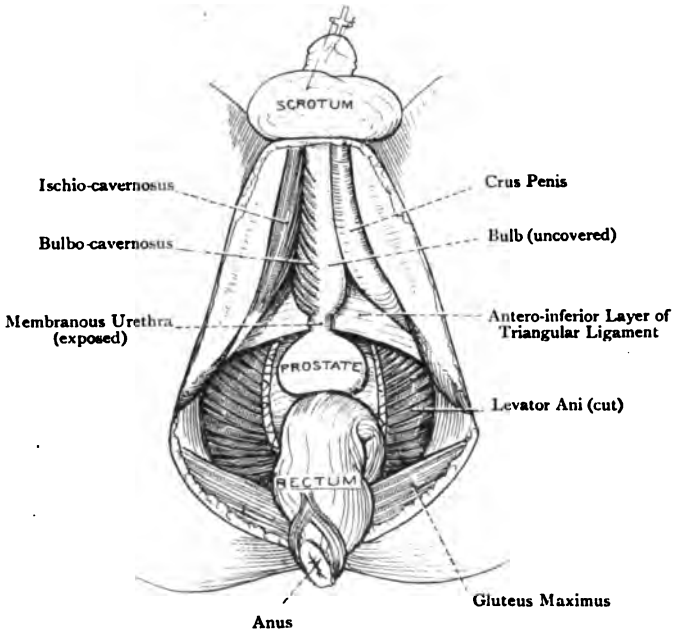


FIG. 268.—DEEP DISSECTION OF THE MALE PERINEUM
(The rectum has been turned back).

Bulbo-cavernosus (accelerator or ejaculator urinæ)—*Origin.*—(1) The central tendinous point of the perineum ; and (2) the median raphé, which is continued forwards from that point towards the symphysis pubis.

Insertion.—The muscle, as regards its insertion, is conveniently divided into three parts, namely, the chief part, the anterior part and the posterior part.

Chief Part.—The fibres of this part ascend between the crus penis and the side of the bulb to be inserted into the median raphé on the upper surface of the bulb, where they meet the fibres of the corresponding part of the opposite muscle.

Anterior Part.—The fibres of this part become somewhat detached and form the **muscle of Houston.** They are inserted partly into the outer surface of the fibrous sheath of the corpus cavernosum penis in front of the ischio-cavernosus, and partly by means of a tendinous expansion into the fascial investment of the penis beneath which the dorsal vein of the penis lies.

Posterior Part.—The fibres of this part arch outwards and backwards to be inserted into the antero-inferior layer of the triangular ligament near its base.

Nerve-supply.—The deep division of the perineal branch of the pudic nerve.

Action.—(1) The chief part of the muscle, acting with its fellow, compresses the bulb. These portions of the two muscles, therefore, come into play at the end of the act of micturition, when they expel the last drops of urine from this part of the urethra. A further action is to contribute to the maintenance of erection of the penis by compressing the veins of the bulb. (2) The anterior part compresses the dorsal vein of the penis, and so contributes to the maintenance of erection. (3) The posterior part tends to fix the bulb and maintain it in position.

The chief portions of the bulbo-cavernosi muscles completely surround the bulb, and may be regarded as forming a sphincter muscle to it.

Compressor or **Constrictor Urethræ.**—This muscle is also called the **muscle of Guthrie.** It extends transversely from the inner border of the ischio-pubic ramus of one side to the inner border of the opposite ischio-pubic ramus, lying in each case behind the attachment of the antero-inferior layer of the triangular ligament of the urethra. At the middle line the muscle divides into two layers, which, passing above and below the membranous part of the urethra, form a sphincter muscle to it, the lower layer also ensheathing the glands of Cowper. The posterior fibres of the muscle, which lie close to the base of the triangular ligament, are known as the **transversus perinæi profundus** (Henle). The highest fibres are connected on either side with the pelvic surface of the descending pubic ramus at its upper part, and they join each other below the membranous portion of the urethra. These highest fibres, which are oblique in direction, constitute the **levatores urethræ muscles,** or **muscles of Wilson.**

Nerve-supply.—The dorsal nerve of the penis.

Action.—(1) To constrict the membranous part of the urethra. The muscle comes into play at the end of micturition, and it assists the bulbo-cavernosus in emptying the urethral canal. (2) To contribute to the maintenance of erection of the penis by compressing the plexus of veins, in the muscle, which receives its tributaries from the corpora cavernosa and bulb. (3) To compress Cowper's glands, and so aid in the expulsion of their secretion.

The compressor urethræ muscle lies between the two layers of the triangular ligament of the urethra. Close to its attachment to

the ischio-pubic ramus it contains within its substance the internal pudic vessels and the dorsal nerve of the penis.

Central Tendinous Point.—Nearly 1 inch in front of the anus there is a short transverse tendinous septum, about ½ inch long. At its centre it presents a thickening, to which the name of *central tendinous point* is given. The muscles which meet at this point are as follows: (1) the sphincter ani externus, coming from behind; (2) the bulbo-cavernosi, coming from before; (3) the superficial transverse perineal muscles, coming from either side; and (4) the anterior portions of the levatores ani, which here lie above the posterior portions of the bulbo-cavernosi. The pointed process at the centre of the base of the antero-inferior layer of the triangular ligament of the urethra is also attached to the central tendinous point.

Bulb of the Urethra.—This is the first part of the corpus spongiosum penis, and is so named from its presenting a bulbous enlargement. It measures about 1½ inches in length, and about ¾ inch in breadth at its posterior part. Its posterior extremity rests upon the antero-inferior layer of the triangular ligament, and extends as far back as the central tendinous point, where it lies nearly 1 inch in front of the anus. This part extends fully ¼ inch farther back than the bulbous part of the urethra. It here presents on its under surface, in the middle line, a faint groove indicative of a tendency to a bipartite division at this point. The bulb is invested by a fibrous sheath derived from the circumference of the urethral opening in the antero-inferior layer of the triangular ligament, superficial to which lie the fibres of the chief parts of the bulbo-cavernosi muscles. Each lateral wall of the bulb is pierced by Cowper's duct, which, with its fellow of the opposite side, opens upon the floor of the bulbous part of the urethra fully 1 inch in front of the antero-inferior layer of the triangular ligament.

Crus Penis (crus corporis cavernosi penis).—This is the posterior attached portion of the corpus cavernosum penis. It is attached to the anterior everted lip of the inner border of the ischio-pubic ramus, superficial to the antero-inferior layer of the triangular ligament. Inferiorly and laterally it is covered by the ischio-cavernosus, and it lies beneath the fascia of Colles. The artery of the corpus cavernosum, having pierced the antero-inferior layer of the triangular ligament, passes between the attached surface of the crus and the ischio-pubic ramus, and enters the deep surface of the crus, to be continued forwards in the centre of the corpus cavernosum.

Deep Perineal Triangle—Boundaries—*External.*—The crus penis, covered by the ischio-cavernosus muscle. *Internal.*—The bulb of the urethra, covered by the bulbo-cavernosus muscle. *Posterior*, or *Base.*—The superficial transverse perineal muscle. The *floor* is formed by the fascia of Colles, with the superficial perineal vessels and the three long scrotal nerves. In the undisturbed position o

the parts the area of the triangle is concealed by the approximation of the bulbo-cavernosus and ischio-cavernosus muscles. When, however, these muscles are held apart there is seen lying deeply in the area one half of the antero-inferior layer of the triangular ligament of the urethra.

Subpubic Ligament (ligamentum arcuatum).—This is a thick band which lies at the antero-superior part of the subpubic arch, where it fills up the subpubic angle. It is attached superiorly to the lower part of the interpubic disc, and laterally to the adjacent parts of the inner lips of the descending pubic rami. It is about ¼ inch in depth, and is slightly arched.

Transverse Pelvic or Perineal Ligament.—This band extends transversely between the descending pubic rami two or three lines below the subpubic ligament. Inferiorly it is closely connected with the truncated apex of the antero-inferior layer of the triangular ligament. Between its upper border and the subpubic ligament there is the opening for the backward passage of the dorsalis penis vein.

Triangular Ligament of the Urethra.—This ligament occupies the subpubic arch, which it fills, except at its antero-superior part where it is replaced by the subpubic and transverse pelvic or perineal ligaments. It is composed of two distinct layers, called antero-inferior (perineal) and postero-superior (pelvic). These two layers are united by their bases, but elsewhere they are separated by an interval of about ½ inch, in which the membranous part of the urethra in the male, and the vagina and urethra in the female, along with other structures to be presently enumerated, lie.

The **antero-inferior layer** is also called the **subpubic, or deep perineal, fascia.** It is triangular, the apex being truncated. The *apex* is closely connected with the transverse pelvic or perineal ligament, which may be regarded as a part of its fibres. Each *lateral margin* is attached to the inner border of the ischio-pubic ramus, behind its everted lip, on which it extends as far back as the tuber ischii, lying between the attachments of the crus penis and ischio-cavernosus anteriorly and the compressor urethræ posteriorly. In this direction it measures fully 2 inches. The *base* is directed downwards and backwards, and is joined by the base of the postero-superior layer and the fascia of Colles. In the middle line the base is projected into a slight process, which is connected with the central tendinous point of the perineum. On either side of this median process the base presents a concave margin where it sweeps downwards and outwards to the tuber ischii. The length of the antero-inferior layer in the middle line is about 1½ inches. Its fibres are chiefly disposed transversely. The structures which pierce this layer are as follows: the urethra, the arteries of the bulb, the arteries of the corpora cavernosa penis, the dorsal arteries and the dorsal nerves of the penis, the superficial perineal vessels and nerves, and the ducts of Cowper's glands.

Urethral Opening.—This aperture is situated in the middle line

fully 1 inch below the subpubic angle, and it gives exit to the membranous part of the urethra. From the circumference of the opening an expansion is given off, which forms a fascial investment for the bulb.

Openings for the Arteries of the Bulb.—These are two in number, right and left, and are situated one on either side of the upper part of the urethral opening.

Openings for the Arteries of the Corpora Cavernosa Penis.—These are two in number, right and left, and each is situated in the lateral attached border, under cover of the crus penis, about 1 inch below the level of the subpubic angle.

Openings for the Dorsal Arteries and Nerves of the Penis.—These are two in number on either side, and are situated high up,

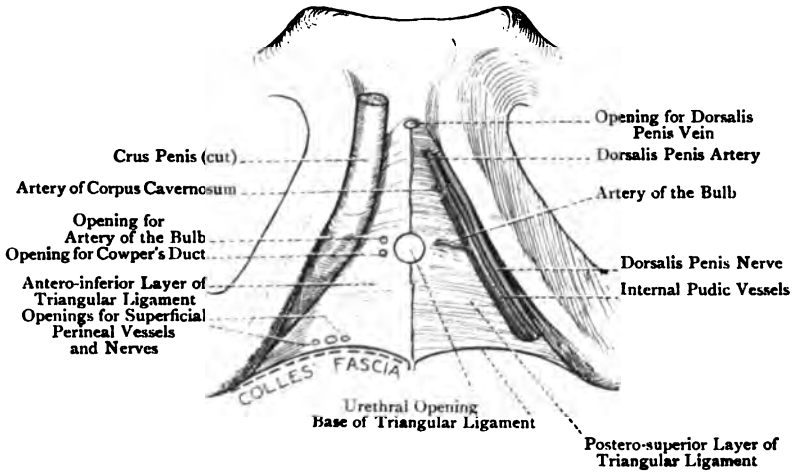

Opening for Dorsalis Penis Vein
Crus Penis (cut)
Dorsalis Penis Artery
Artery of Corpus Cavernosum
Artery of the Bulb
Opening for Artery of the Bulb
Opening for Cowper's Duct
Dorsalis Penis Nerve
Antero-inferior Layer of Triangular Ligament
Internal Pudic Vessels
Openings for Superficial Perineal Vessels and Nerves
COLLES FASCIA
Urethral Opening
Base of Triangular Ligament
Postero-superior Layer of Triangular Ligament

FIG. 269.—THE TRIANGULAR LIGAMENT OF THE URETHRA
(The antero-inferior layer has been removed on the left side).

being near the subpubic angle, and close to the descending pubic ramus, the opening for the artery being internal to that for the nerve. It is to be noted that the dorsal vein of the penis has a special opening, which is situated in the median line between the subpubic and transverse pelvic or perineal ligaments.

Openings for the Superficial Perineal Vessels and Nerves.—These are situated, on either side, in the base at the line of junction with the fascia of Colles.

Openings for the Ducts of Cowper's Glands.—Each of these is situated on either side of the urethral aperture a little behind and below the opening for the artery of the bulb.

Chief Relations—*Antero-inferior.*—The bulb of the urethra, and the crura penis, covered by their respective muscles, the superficial transverse perineal muscles, and the fascia of Colles. *Postero-*

superior.—The membranous part of the urethra, the glands of Cowper, and the compressor urethræ muscle.

The **postero-superior layer** is weaker and much less defined than the antero-inferior. It lies about ½ inch above and behind that layer, and extends inwards to the urethra from the inner aspect of each ischio-pubic ramus near the posterior lip, where it is behind the compressor urethræ muscle. Superiorly it is attached to the transverse pelvic or perineal ligament, and its base joins that of the antero-inferior layer. At each ischio-pubic ramus it is continuous with the parietal pelvic fascia. When it arrives at the urethra it changes its course, and passes backwards over the anterior border of the levator ani muscle to blend with that portion of the visceral pelvic fascia which ensheathes the prostate gland. The postero-superior layer of the triangular ligament is to be regarded as a part of the parietal pelvic fascia. Antero-inferiorly it is in contact with the membranous part of the urethra and compressor urethræ muscle, whilst postero-superiorly it is related to the anterior fibres of the levator ani of each side, and forms the floor of the anterior diverticulum of the ischio-rectal fossa. The structures which pierce this layer are as follows: the membranous part of the urethra in the male, and the vagina and urethra in the female; and the internal pudic vessels and dorsal nerves of the penis.

Urethral Opening.—This is often a mere cleft, in which cases the postero-superior layer may be described as being arranged in two symmetrical halves. At this opening or cleft it becomes continuous superiorly with the capsule of the prostate gland.

Openings for the Internal Pudic Vessels and Dorsal Nerves of the Penis.—These are situated close to the base, on either side, near the ischial ramus.

Structures between the Layers of the Triangular Ligament.—These are as follows:

1. The membranous portion of the urethra in great part.
2. The glands of Cowper.
3. The compressor urethræ muscle.
4. The internal pudic arteries, each lying close to the ischio-pubic ramus in the compressor urethræ muscle, and each giving off the following branches: (*a*) the artery of the bulb, which in turn gives off the artery of a Cowper's gland; (*b*) the artery of the corpus cavernosum; and (*c*) the dorsal artery of the penis.
5. A plexus of veins which receives its tributaries from the crus (corpus cavernosum) and bulb, and in which the internal pudic venæ comites take their origin.
6. The deep lymphatics of the penis.
7. The dorsal nerves of the penis, each of which lies external to the corresponding internal pudic artery.

Glands of Cowper.—These glands are two in number, right and left. They are situated between the two layers of the triangular ligament, where they lie above the bulb and behind the membranous portion of the urethra, one on either side of the median

line. Each gland is a firm, round, and lobulated mass about the size of a small pea. Both glands are ensheathed by the lower layer of the compressor urethræ muscle, and within this there is the special fibrous capsule which has an admixture of plain muscular tissue. The glands belong to the class of racemose or acino-tubular glands, and each is composed of several lobules. The alveoli or acini are lined with columnar cells. The ducts are two in number, right and left. They are lined with cubical epithelium, and their walls contain plain muscular tissue. Each duct pierces the antero-inferior layer of the triangular ligament on either side of the urethral opening, a little behind and below the artery of the bulb. The duct then pierces the side of the bulb, and opens, with its fellow, upon the floor of the bulbous part of the urethra, fully 1 inch in front of the antero-inferior layer of the triangular ligament. Each gland receives a branch from the artery of the bulb.

Cowper's glands are developed from the epithelial lining of the uro-genital sinus or canal.

Internal Pudic Artery.—This vessel is one of the terminal branches of the anterior division of the internal iliac, the other and larger terminal branch being the sciatic. Lying at first within the pelvis, the artery passes downwards over the pyriformis muscle and sacral nerves, having the sciatic artery usually behind it, and it emerges from the cavity through the lower compartment of the great sacro-sciatic foramen. It then crosses the back of the spine of the ischium, after which it passes through the small sacro-sciatic foramen, and so enters the ischio-rectal division of the perineum. The vessel now courses along the outer wall of the ischio-rectal fossa, where, contained in Alcock's canal, it lies about 1½ inches above the lower part of the tuber ischii. On approaching the anterior part of the fossa the artery gradually becomes more superficial, and, after leaving the fossa, it enters the interspace between the two layers of the triangular ligament of the urethra by piercing the postero-superior layer close to its base and near the ischial ramus. It now passes forwards and upwards, embedded in the compressor urethræ muscle, and lying close to the ischio-pubic ramus, where it is comparatively superficial. Having given off the artery of the bulb about ½ inch above the base of the triangular ligament, the vessel finally divides, about 1 inch below the subpubic angle, into its two terminal branches, the artery of the corpus cavernosum and the dorsal artery of the penis.

In considering the relations and branches of the internal pudic artery it is convenient to divide the vessel into four parts—first, second, third, and fourth.

The **first part** represents the intrapelvic portion of the vessel, and will be found described on p. 788.

The **second part** is the portion of the vessel which lies upon the back of the spine of the ischium. For a description of it see p. 408.

The **third part** is the part of the vessel which lies on the outer wall of the ischio-rectal fossa. It is here contained in Alcock's canal, and is situated about 1½ inches above the lower part of the tuber ischii. For its relations see Alcock's canal.

Branches.—These are as follows: the inferior hemorrhoidal, the superficial perineal, and the transverse perineal.

The **inferior hemorrhoidal artery** arises, either singly or in two or three branches, from the internal pudic immediately after it has taken up its position in Alcock's canal. The branches pass inwards to the anal canal through the loose fat which fills the ischio-rectal fossa. They are distributed to the external sphincter, levator ani, wall of the anal canal, and superficial structures of one half of the ischio-rectal division of the perineum, and they anastomose with the middle and superior hemorrhoidal arteries, and the inferior hemorrhoidal branches of the opposite side.

The **superficial perineal artery** arises from the internal pudic at the anterior part of the ischio-rectal fossa. It pierces the base of the antero-inferior layer of the triangular ligament, and passes superficial to (sometimes on the deep surface of) the superficial transverse perineal muscle. Its subsequent course is forwards under cover of the fascia of Colles, where it lies in the floor of the deep perineal triangle, in company with the three long scrotal nerves. On approaching the scrotum it divides into several long slender branches, which supply the back of the scrotum and anastomose with the external pudic branches of the common femoral artery.

The **transverse perineal artery,** as a rule, arises in common with the superficial perineal, of which it is sometimes regarded as a branch. It may, however, arise directly from the internal pudic immediately in front of the origin of the superficial perineal. It is directed inwards and forwards to the central tendinous point lying superficial to the superficial transverse perineal muscle, and beneath the fascia of Colles. It supplies the muscles which meet at the central tendinous point, and anastomoses with its fellow of the opposite side.

Alcock's Canal.—This canal is situated in the outer wall of the ischio-rectal fossa, and is formed by the obturator fascia. Its contents from below upwards are as follows: (1) the perineal division of the pudic nerve; (2) the lower vena comes; (3) the third part of the internal pudic artery; (4) the upper vena comes; and (5) the dorsal nerve of the penis.

The **fourth part** of the internal pudic artery lies between the two layers of the triangular ligament. It enters this interspace by piercing the postero-superior layer of that ligament close to its base and near the ischial ramus. It is embedded in the compressor urethræ muscle, and is comparatively superficial. As it lies near the ischio-pubic ramus it has a vena comes on either side of it, and the dorsal nerve of the penis is external to it.

Branches.—These are as follows: the artery of the corpus

spongiosum, the artery of the corpus cavernosum, and the dorsal artery of the penis.

The **artery of the corpus spongiosum (artery of the bulb)** arises from the internal pudic about ½ inch above the base of the triangular ligament, and passes transversely inwards in the substance of the compressor urethræ muscle. On approaching the urethra it turns forwards, and, having pierced the compressor urethræ, it passes through an opening in the antero-inferior layer of the triangular ligament at the side of the urethral aperture. It then enters the bulb, and is continued onwards in the corpus spongiosum as far as the glans penis, the erectile tissue of which parts it supplies. It anastomoses with its fellow of the opposite side and with the dorsal arteries of the penis. Whilst between the two layers of the triangular ligament the artery furnishes a branch to Cowper's gland of the corresponding side.

The **artery of the corpus cavernosum** is one of the two terminal branches of the internal pudic, and is somewhat larger than the dorsal artery of the penis, which is the other terminal branch. It arises about 1 inch below the subpubic angle, and immediately thereafter pierces the compressor urethræ muscle and the antero-inferior layer of the triangular ligament close to the ischio-pubic ramus. It then passes between the bone and the crus, and, entering the crus on its deep surface, it is continued onwards in the centre of the corpus cavernosum as far as the distal end of that body, the erectile tissue of which it supplies.

The **dorsal artery of the penis** is the continuation of the internal pudic. For a very short distance it lies between the two layers of the triangular ligament embedded in the compressor urethræ muscle, its course here being upwards. It then turns forwards, and, having pierced that muscle and the antero-inferior layer of the ligament very near its upper part, it ascends between the crus and the symphysis pubis. Its subsequent course is between the two layers of the suspensory ligament of the penis, and then along the dorsum of the organ, where it has the centrally-placed dorsal vein on its inner side and the dorsal nerve of the penis on its outer. On arriving at the neck of the penis it ends in branches for the supply of the glans and prepuce, where it anastomoses with its fellow of the opposite side and the arteries of the corpus spongiosum. In its course along the dorsum of the penis the artery gives off many branches, some of which supply the integument and anastomose with the superior external pudic of the common femoral, whilst others pierce the fibrous sheath of the corpus cavernosum to supply its erectile tissue, these latter anastomosing with the artery of the corpus cavernosum.

Varieties of the Internal Pudic Artery—1. **Trunk.**—The vessel is occasionally of small size, and may terminate in the artery of the bulb, or in the superficial perineal artery. In these cases an **accessory pudic artery** is present, which supplies the deficiencies. This vessel usually arises from the first or intrapelvic part of the internal pudic, though it may spring from an inferior

vesical artery. Its course is forwards along the side of the bladder, then along the side of the prostate gland to the triangular ligament of the urethra, which it pierces above the membranous part of the canal, and so reaches the root of the penis. The accessory pudic furnishes the artery of the corpus cavernosum and the dorsal artery of the penis, and in some cases the artery of the bulb.

2. **Artery of the Corpus Spongiosum (Artery of the Bulb).**—Sometimes two arteries are present on one side; sometimes the artery is absent on one side; and sometimes it is of very small size. A much more important variety of this artery affects its origin. It may arise from the fourth part of the internal pudic close to the base of the triangular ligament, and even from the third part at the front of the ischio-rectal fossa. In these cases the artery cannot escape division in the operation of lateral lithotomy. In other cases it may arise from an accessory pudic artery, when it will lie higher up and further forwards than usual.

3. **Dorsal Artery of the Penis.**—This vessel may arise from the obturator artery in the obturator canal, or from one of the external pudic branches of the common femoral artery.

Veins.—Lying in each compressor urethræ muscle there is a plexus of veins, which receives its tributaries from the corresponding corpus cavernosum and one half of the corpus spongiosum and bulb. The **internal pudic venæ comites** arise on either side from this plexus, and accompany the internal pudic artery as far back as the upper border of the spine of the ischium, one lying on either side of the vessel. Here they join to form one trunk, which enters the pelvis through the lower compartment of the great sacro-sciatic foramen, and terminates in the internal iliac vein. They receive as tributaries the transverse perineal, superficial perineal, and inferior hemorrhoidal veins, as well as a few veins from the gluteus maximus and external rotator muscles. The **inferior hemorrhoidal veins** take their origin in a plexus of veins which is situated on the outer surface of the external sphincter muscle. Having crossed the ischio-rectal fossa through its loose fat, and being ultimately reduced to two or three in number, they join the internal pudic venæ comites.

It is to be noted that, though there are two dorsal arteries, there is only one dorsal vein, which takes the following course: after leaving the dorsum of the penis it passes through an opening between the subpubic and transverse pelvic or perineal ligaments, where it communicates on either side with the venous plexus in each half of the compressor urethræ muscle. Having entered the cavity of the pelvis, it divides into two branches, right and left, which join the prostatic plexus of veins.

Lymphatics.—The **superficial lymphatics** of the perineum, as well as those of the anus and lower part of the anal canal, pass to the *inguinal glands*, which lie immediately below Poupart's ligament, whilst the **deep lymphatics** pass to the *internal iliac glands*.

Pudic Nerve.—The pudic nerve is one of the terminal branches of the sacral plexus, and derives its fibres from the ventral division of the second, the lower branch of the third, and the upper branch of the fourth sacral nerves, the majority of its fibres being derived from the lower branch of the third. Leaving the pelvis through the lower compartment of the great sacro-sciatic foramen, the nerve

crosses the back of the spine of the ischium, where it lies under cover of the gluteus maximus and on the inner side of the internal pudic vessels. It then passes through the small sacro-sciatic foramen, and so enters Alcock's canal in the outer wall of the ischio-rectal fossa. Immediately after doing so, it divides into three branches, namely, inferior hemorrhoidal, perineal, and dorsal nerve of the penis.

The **inferior hemorrhoidal nerve** passes inwards across the ischio-rectal fossa to the region of the anus, and is distributed to the external sphincter muscle and the integument which covers the ischio-rectal fossa.

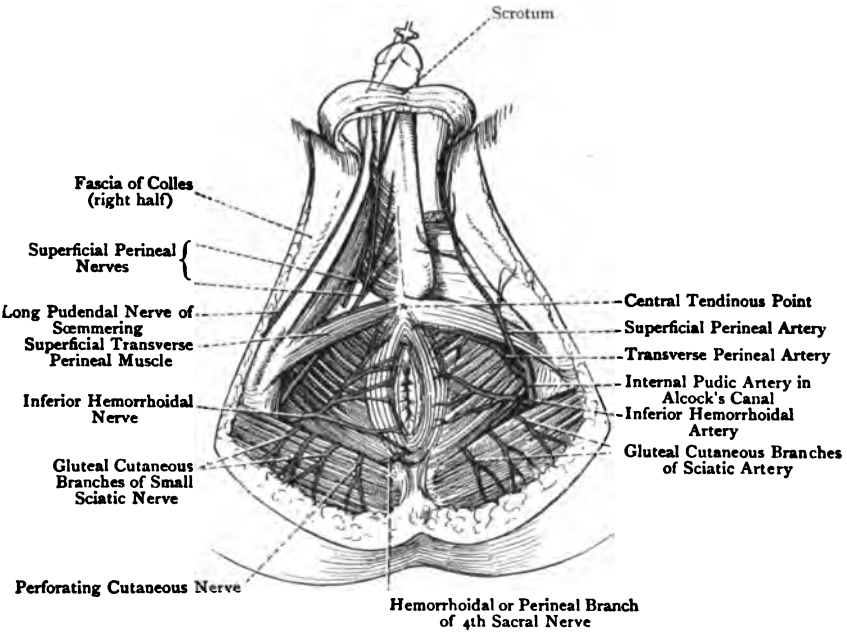

Scrotum
Fascia of Colles (right half)
Superficial Perineal Nerves
Long Pudendal Nerve of Sœmmering
Superficial Transverse Perineal Muscle
Inferior Hemorrhoidal Nerve
Gluteal Cutaneous Branches of Small Sciatic Nerve
Perforating Cutaneous Nerve
Central Tendinous Point
Superficial Perineal Artery
Transverse Perineal Artery
Internal Pudic Artery in Alcock's Canal
Inferior Hemorrhoidal Artery
Gluteal Cutaneous Branches of Sciatic Artery
Hemorrhoidal or Perineal Branch of 4th Sacral Nerve

FIG. 270.—DISSECTION OF THE MALE PERINEUM

(On the left side the bulbo-cavernosus has been removed, and the crus penis cut).

The **perineal nerve** is a large branch which passes forwards in Alcock's canal, being the lowest of its contents. It ultimately divides into superficial and deep branches.

The *superficial branches* are two in number, and are called the *external* or *posterior*, and *internal* or *anterior*, *superficial perineal nerves*. Both nerves, having emerged from Alcock's canal, pass forwards and pierce the base of the antero-inferior layer of the triangular ligament. They then run forwards with the superficial perineal artery under cover of the fascia of Colles, and on approach-

ing the back of the scrotum they divide into long slender branches, which supply the scrotal integument.

In the anterior division of the perineum the two superficial perineal nerves communicate freely, and are accompanied by the **long pudendal nerve of Sœmmering**, which is a branch of the small sciatic. This nerve, having pierced the fascia lata about 1 inch in front of the tuber ischii, passes inwards over the ischio-pubic ramus and through the fascia of Colles. It then runs forwards and inwards beneath that fascia to the scrotum, to take part in the supply of its integument, and it communicates with the external or posterior superficial perineal nerve.

The two superficial perineal nerves and the long pudendal nerve are known as the **long scrotal nerves.**

The *deep branch of the perineal nerve* furnishes offsets which, with one exception, are muscular in their distribution, and supply the anterior part of the external sphincter, the anterior part of the levator ani, the superficial transverse perineal, the ischio-cavernosus, and the bulbo-cavernosus. The non-muscular branch, called the nerve of the bulb, pierces the bulbo-cavernosus muscle and the wall of the bulb, to be distributed to the erectile tissue of the corpus spongiosum and the mucous membrane of the spongy part of the urethra.

The **dorsal nerve of the penis** is at first contained in Alcock's canal, where it lies above the internal pudic vessels. Having emerged from that canal, it pierces the postero-superior layer of the triangular ligament near its base. It then passes forwards and upwards, with the fourth part of the internal pudic artery, between the two layers of the triangular ligament, in which situation it lies on the outer side of the internal pudic vessels, and close to the ischio-pubic ramus, being embedded in the compressor urethræ muscle. Its subsequent course is similar to that of the dorsal artery of the penis, which it accompanies. On the dorsum of the penis, where it lies external to the dorsal artery, it is continued as far as the glans, where it ends in branches for the glans and prepuce. As the nerve lies between the two layers of the triangular ligament, it gives branches to the compressor urethræ muscle, and it also furnishes the nerve of the corpus cavernosum. This latter nerve, having pierced the compressor urethræ and antero-inferior layer of the triangular ligament, enters the crus, and is continued forwards in the corpus cavernosum to supply the erectile tissue of these parts. As the nerve passes along the dorsum of the penis, it supplies numerous branches to the integument of that organ.

Structures divided in Left Lateral Lithotomy. — The structures divided in this operation are as follows: (1) the skin; (2) the subcutaneous layer of the superficial fascia; (3) the deep layer of the superficial fascia or the fascia of Colles; (4) the transverse perineal vessels; (5) the superficial transverse perineal muscle; (6) the inferior hemorrhoidal vessels and nerve; (7) the basal part of the antero-inferior layer of the triangular ligament; (8) the compressor urethræ muscle and the plexus of veins embedded in it; (9) the

membranous part of the urethra; (10) the postero-superior layer of the triangular ligament; (11) the anterior fibres of the levator ani muscle; (12) a portion of the left lateral lobe of the prostate gland, with its capsule, and some of the veins of the prostatic plexus; and (13) the neck of the bladder.

Structures to be avoided.—The structures to be avoided are as follows: (1) the rectum; (2) the internal pudic vessels as they lie in Alcock's canal; (3) the artery of the bulb; and (4) the common ejaculatory duct.

FEMALE PERINEUM.

The female perineum is divided into three regions—uro-genital, perineum proper, and ischio-rectal. The uro-genital division is situated at the anterior part, and comprises the pudendum and uro-genital cleft. The perineum proper is situated between the posterior part of the uro-genital cleft and the anus. The ischio-rectal division is situated as in the male.

Uro-genital Division.

The uro-genital division contains the external uro-genital organs. These collectively constitute the **pudendum**, and comprise the following parts: the mons Veneris; labia majora; labia minora, or nymphæ; clitoris; vestibule; meatus urinarius; vaginal orifice, including the hymen, or the carunculæ myrtiformes; frænulum pudendi; fossa navicularis; bulbi vestibuli; and glands of Bartholin or of Duverney.

The **mons Veneris** is an eminence situated in front of and above the upper part of the symphysis pubis. It is produced by a collection of adipose tissue, the skin over which is more or less freely provided with hair after the age of puberty.

The **labia majora** are two thick, round folds of integument, which are directed from before backwards, with a slight inclination downwards. The length of each is about 3 inches. Posteriorly they become thin, and join each other at the anterior part of the perineum proper, about 1 inch in front of the anus. The junction receives the name of the **posterior commissure**, and is somewhat pointed. Anteriorly they retain their thick, round character, and here also they join and become continuous with the mons Veneris. This latter junction is called the **anterior commissure**. Each labium majus has two surfaces, outer and inner. The skin covering the outer convex surface is somewhat dark in colour, like that of the scrotum, and contains numerous sebaceous glands of large size. It is also more or less freely provided with hair after the age of puberty, except towards the posterior part. The inner flat surface forms the lateral boundary of the uro-genital cleft, and touches that of the opposite side. The skin covering this surface is smooth and free from hair, and presents the openings of the ducts of sebaceous glands. Each labium majus contains adipose and areolar tissues, and a small amount of dartos tissue. The round ligament of the

uterus of each side loses itself in this labium, and the fasciæ of Camper and of Scarpa of the lower part of the anterior abdominal wall of each side also enter it. The fissure between these labia is called the **uro-genital cleft** or **rima pudendi**, and is almost horizontal, its direction being antero-posterior. The blood-supply and nerve-supply of the labia majora correspond with those of the scrotum.

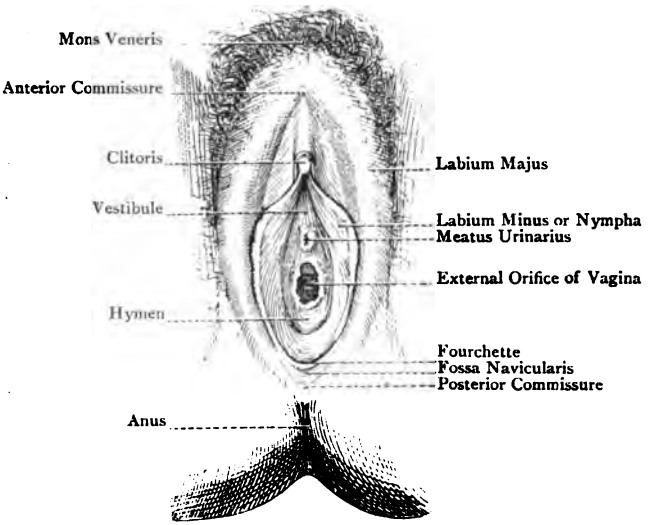


FIG. 271.—THE EXTERNAL GENITAL ORGANS OF THE FEMALE.

The **labia minora**, or **nymphæ**, are two narrow, more or less pendulous folds of integument, which are situated in the uro-genital space, each lying internal to the corresponding labium majus. They become continuous with each other anteriorly, in the region of the clitoris, a short distance from the anterior commissure, in a manner to be presently described. From this point they diverge as they pass backwards, and so form the lateral boundaries of the space called the vestibule. Each terminates posteriorly by blending with the inner surface of the corresponding labium majus, or in some cases by becoming continuous with the frænulum pudendi. Each labium minus has two surfaces, outer and inner, and two borders, superior and inferior. The outer surface is in contact with the inner surface of the labium majus of the same side, and the inner surface touches that of the opposite nympha. Each surface is covered by a modified form of skin, that on the inner surface being extremely delicate, and being somewhat like mucous membrane. The true mucous membrane, however, only commences at the inner side of the base or superior attached border of the labium minus. The labia minora, previous to their union anteriorly,

divide each into two laminæ. The upper and larger lamina passes over the clitoris, and becomes continuous with that of the opposite side, thus forming a cap for that organ, called the **præputium clitoridis.** The lower and smaller lamina passes below the clitoris, where it also becomes continuous with that of the opposite side. At the line of junction of the two lower laminæ they are attached to the under surface of the clitoris, thus forming the **frænulum clitoridis.** The labia minora are destitute of both hair and fat, but they contain sebaceous glands. They sometimes attain a large degree of development, in which cases they project through the uro-genital fissure. In some African women they become so much developed as to reach down to the knees. When this occurs they form what has been called the apron of Hottentots. The labia minora are homologous with the floor of the spongy part of the urethra and the integument of the under surface of the penis and prepuce in the male.

Development of the Labia Majora and Labia Minora.—The anterior part of the cloacal fossa in the female forms the **uro-genital space,** and the margins or lips of this space become prominent and give rise to the **outer genital folds.** At the posterior (lower) part of the uro-genital space there is the **uro-genital cleft,** which receives the external orifices of the urethra and vagina. The lips of this cleft form two other folds, called the **inner genital folds.** The *outer genital folds* form the **labia majora,** and the *inner genital folds* give rise to the **labia minora.** In the male the anterior part of the cloacal fossa (uro-genital furrow) is closed over by the meeting and union of its lips to form the spongy portion of the urethra. The *genital folds,* which correspond with the *outer* genital folds in the female, coalesce in a median raphé, and so give rise to the **scrotum,** which, therefore, corresponds to the labia majora in the female.

The **clitoris** is situated in the uro-genital space a little behind the anterior commissure, and is composed of two corpora cavernosa and a glans. Each **corpus cavernosum** is attached by means of a *crus* to the anterior everted lip of the inner border of the ischio-pubic ramus, the crus being covered by the ischio-cavernosus or erector clitoridis muscle, and lying superficial to the antero-inferior layer of the triangular ligament. The two corpora cavernosa unite by their inner flattened surfaces, and so form the body of the clitoris, which is about 1½ inches long. The septum, which is interposed at the line of junction of the corpora cavernosa, is incomplete, and is called the *septum pectiniforme.* The dorsal surface of the clitoris at its upper end is attached to the front of the symphysis pubis by a small suspensory ligament, and the distal end of the organ is capped by an imperforate glans. The *glans,* which caps the corpora cavernosa, is composed of erectile tissue, and is extremely sensitive. It is provided with a prepuce and a frænulum, both of which are continuous with the labia minora. The organ is composed of erectile tissue.

The clitoris is the homologue of the penis, from which it differs in the following respects : (1) the only part of a corpus spongiosum which it possesses is the glans (the part of the corpus spongiosum

of the male which lies between the bulb and the glans penis being represented in the female by the *pars intermedia* of the bulbi vestibuli) ; (2) it does not contain the female urethra ; and (3) its component parts are much smaller than those of the penis. In reality the clitoris is a diminutive penis, minus the corpus spongiosum and the urethra.

The **vestibule** is the space which is enclosed by the labia minora, and is so called because it is the 'porch' of the vagina. It is triangular, the apex, which is in front, being formed by the glans clitoridis, the lateral boundaries by the labia minora, and the base, which is directed backwards, by an imaginary line passing transversely in front of the external orifice of the vagina and behind the meatus urinarius. It is about 1 inch in length, and presents a smooth surface formed by mucous membrane, which is covered by stratified squamous epithelium. At its posterior extremity, in the middle line, and immediately in front of the external orifice of the vagina, there is a slight prominence, with somewhat irregular margins. Upon this prominence the **meatus urinarius** is situated at a point 1 inch behind the clitoris. The irregular prominence serves as a guide to this opening.

The vestibule represents the remains of the uro-genital sinus.

The **external orifice of the vagina** is situated immediately behind the vestibule. It is an antero-posterior cleft, having an elliptical shape when partially dilated. The portion of the vagina close above it is the narrowest part of the passage. For the description of the vagina, see p. 832.

The **hymen** in its normal condition is a thin semilunar fold of mucous membrane which is stretched across the posterior third, or half, of the external orifice of the vagina. Its concave border, which is free, is directed forwards and upwards. Sometimes the hymen completely surrounds the circumference of the orifice, an aperture being left in its centre. In other cases it stretches over the entire opening, but is perforated by apertures which give it a cribriform appearance. In rare cases it is an entire membrane, completely shutting off the vaginal canal from the uro-genital space, and it is then spoken of as an imperforate hymen. In some cases, even in the virgin, it is entirely absent.

The hymen begins to appear about the fifth month of intra-uterine life as a fold of the mucous membrane at the point where the vagina opens into the uro-genital sinus.

The **carunculæ myrtiformes** are small elevations which represent the remains of the hymen after its disappearance. Though called *carunculæ* (fleshy), they are really mucous excrescences.

The **fourchette,** or **frænulum pudendi,** is a crescentic fold of the uro-genital lining membrane which is situated a little in front of the posterior commissure, and it is best marked in early life.

The **fossa navicularis** is a small depression which lies between the posterior commissure and the fourchette.

The **bulbi vestibuli** are two ovoid masses of erectile tissue 1 inch in length, which are situated on either side of the external orifice of the vagina and vestibule beneath the mucous membrane. Each bulb is covered by a delicate fibrous capsule derived from the antero-inferior layer of the triangular ligament, superficial to which the bulb of either side lies. The outer surface is convex, and is covered by one half of the sphincter vaginæ muscle. The inner surface is slightly concave, and is covered by the vaginal mucous membrane. Posteriorly the bulbs diverge, and anteriorly, having become narrow, they pass upwards and forwards, and ultimately meet in the middle line, where they are attached to the antero-

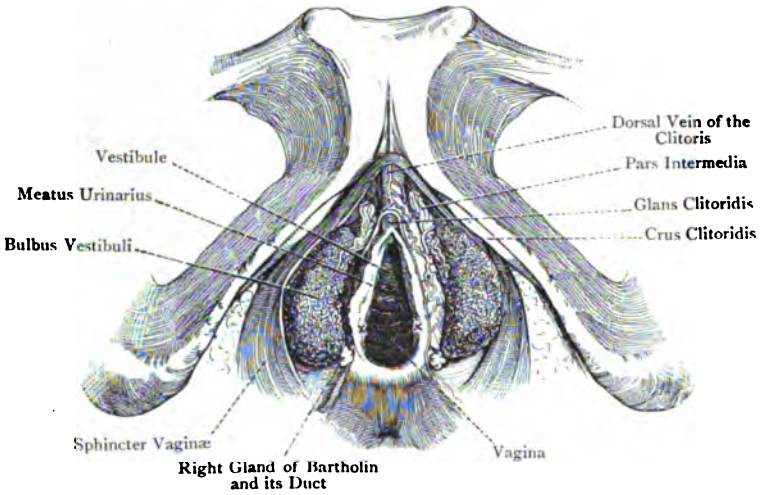


FIG. 272.—DISSECTION SHOWING THE BULBI VESTIBULI AND GLANDS OF BARTHOLIN (MODIFIED FROM KOBELT)

(The cross on either side of the Vaginal Orifice shows the position of the opening of the Duct of Bartholin's Gland).

inferior layer of the triangular ligament. In front of the bulbs there is a plexus of veins which is continuous behind with their erectile tissue, and in front with that of the glans clitoridis. This plexus of veins is known as the **pars intermedia of Kobelt.** It receives its veins from the labia minora, and its blood is conveyed into the vaginal plexus.

The bulbi vestibuli, together, represent the bulb of the male urethra, which latter presents on its under surface a faint groove in the middle line, indicating a tendency to a bipartite division. The pars intermedia of Kobelt is regarded as representing that part of the male corpus spongiosum which extends from the bulb to the glans penis.

The **glands of Bartholin** or **of Duverney** belong to the class of racemose or acino-tubular glands. They are two in number, right and left, and each resembles a small bean. They lie on either side of the external orifice of the vagina towards its back part, immediately behind the posterior extremities of the bulbi vestibuli, and superficial to the base of the triangular ligament. The duct of each gland is about ¾ inch long, and opens in the angle between the attached border of the nympha posteriorly and the hymen or its remains, close to the centre of the margin of the vaginal orifice.

These glands are homologous with the glands of Cowper, and their structure is similar.

The glands of Bartholin are developed from the lining epithelium of the uro-genital sinus.

The external uro-genital organs of the female have received the name of **vulva**. As this word, however, literally signifies 'a covering,' it is strictly applicable only to the labia majora, which by their approximation form a covering for the uro-genital space and its contents.

Perineum Proper.

The perineum proper is the region which lies between the anus and the posterior commissure, and it presents a raphé in the middle line. It is in this division that the perineal body is situated, as well as the central tendinous point. The latter, being similar to that of the male, requires no special description.

Perineal Body.—This body is peculiar to the female perineum. It is situated between the anus and the posterior commissure, and it may be regarded as a deep expansion of the central tendinous point. It is triangular, and is about 1½ inches in breadth. It is bounded *in front* by the posterior wall of the vagina, *behind* by the anterior wall of the anal canal, and *inferiorly* by the integument. The perineal body is produced by a thickening of connective tissue, with a free admixture of elastic tissue, and a few muscular fibres derived from the external sphincter, levatores ani, and sphincter vaginæ muscles. It serves as a support to the posterior wall of the vagina. During parturition it becomes greatly stretched, but its elastic tissue usually guards it against rupture.

Triangular Ligament.—The triangular ligament resembles that of the male in being composed of two layers, antero-inferior and postero-superior.

The **antero-inferior layer**, on account of the greater width of the subpubic arch in the female, is broader than in the male, though it is more indefinite on account of its being pierced by the vagina. It is attached at either side to the inner border of the ischio-pubic ramus, and superiorly to the transverse pelvic or perineal ligament. In the middle line, where it is pierced by the vagina, it blends with the wall of that canal. Its base is joined by a somewhat indefinite layer of fascia representing the fascia of

Colles in the male, and by the postero-superior layer. The openings in the antero-inferior layer are similar to those in the male, with this exception, that the ducts of the glands of Bartholin do not pierce it as the ducts of the glands of Cowper do in the male, the glands of Bartholin being situated superficial to this layer. The urethral opening is situated 1 inch below the symphysis pubis. The opening for the vagina, which is of large size, lies below the urethral orifice, from which it is separated by a few fibres. The openings for the arteries of the bulbi vestibuli are situated one on either side of the vaginal opening. The openings for the artery of the corpus cavernosum clitoridis, for the dorsal artery and nerve of the clitoris, and for the superficial perineal vessels and nerves, all of each side, are situated as in the male.

It is to be noted that the dorsal vein of the clitoris, like the corresponding vessel in the male, passes between the subpubic and transverse pelvic or perineal ligaments.

The **postero-superior layer** is similar to the corresponding layer in the male, and it presents openings for the urethra, vagina, and internal pudic vessels and pudic nerves of each side.

Ischio-rectal Division.

The chief characters of the ischio-rectal division in the female are as follows: the aperture of the anus is somewhat nearer the coccyx than in the male, the distance between the ischial tuberosities is greater than in the male, and the ischio-rectal fossæ are wider and shallower than in the male.

Muscles.—The muscles of the female perineum, as compared with those of the male, present certain differences.

Levatores Ani.—The anterior fibres of these muscles embrace the vagina instead of the prostate gland, as in the male.

Ischio-cavernosus (erector clitoridis).—This muscle replaces the erector penis, and is of small size.

Bulbo-cavernosus or **Sphincter Vaginæ.**—This muscle arises from the central tendinous point, where it meets the external sphincter and superficial transverse perineal muscles. It then passes forwards and divides into two symmetrical parts which surround the vaginal orifice and vestibule, each part closely embracing the outer surface of the corresponding bulbus vestibuli. Anteriorly the two parts become very narrow, and each is inserted into the fibrous sheath of the corpus cavernosum. A few fibres are here detached to be inserted into a tendinous expansion on the dorsum of the clitoris covering the dorsal vein, which vessel would be thereby compressed when the muscle is in action. Some of the inner fibres of the sphincter vaginæ are inserted into the mucous membrane of the vestibule.

The sphincter vaginæ is homologous with the bulbo-cavernosi in the male.

Compressor or **Constrictor Urethræ.**—This muscle, as in the male, lies between the two layers of the triangular ligament. It is

attached, on either side, to the inner margin of the ischio-pubic ramus, and in the middle line it is almost completely divided into two parts by the vagina. The anterior part passes transversely across the subpubic arch in front of the urethra, whilst the posterior and larger part passes inwards, partly transversely and partly obliquely, to blend with the vaginal wall.

The external sphincter and superficial transverse perineal muscles are similar to those in the male.

Internal Pudic Artery.—This vessel is of smaller size than in the male, but it takes a similar course. The difference, therefore, in the two sexes affects chiefly the branches of the artery.

The **superficial perineal artery** is larger than in the male, and is distributed to the labium majus.

The **artery of the bulb** is of comparatively small size, and is distributed to the bulbus vestibuli.

The **artery of the corpus cavernosum clitoridis,** having pierced the antero-inferior layer of the triangular ligament, enters the crus clitoridis, and is then continued onwards in the centre of the corpus cavernosum.

The **dorsal artery of the clitoris,** like the preceding, is comparatively small in size. Having pierced the antero-inferior layer of the triangular ligament, it passes between the crura clitoridis, and also between the two layers of the suspensory ligament of the clitoris. It is then continued along the dorsum of that organ as far as the glans, having the dorsal vein of the clitoris on its inner side, and the dorsal nerve of the clitoris on its outer side. On reaching the glans, it divides into branches for the supply of the glans and its prepuce. As it passes along the dorsum of the clitoris it gives off several branches, which enter the corpus cavernosum by piercing its fibrous sheath.

The **veins** of the female perineum are so similar to those in the male as not to require any special description. An exception, however, has to be made in the case of the **dorsal vein of the clitoris.** This vein is formed by branches which return the blood from the glans and prepuce, and also to a certain extent from the corpora cavernosa. It passes backwards in the groove between the corpora cavernosa, where it has on either side of it the dorsal artery, and external to this the dorsal nerve, of the clitoris. In this part of its course it receives tributaries from the corpora cavernosa. On reaching the root of the organ it passes between the two layers of the suspensory ligament of the clitoris, and then between the subpubic and transverse pelvic or perineal ligaments, and so it enters the pelvic cavity, where it terminates in the plexus of veins at the neck of the bladder.

Lymphatics.—The lymphatics of the labia majora, the superficial lymphatics of the clitoris, including those of its glans, and the lymphatics of the *lower third* of the vagina and of the urethra terminate in the *inguinal glands*, which lie immediately below Poupart's ligament. The lymphatics of the *upper two-thirds* of

the vagina terminate in the *internal iliac glands*, and the deep lymphatics of the corpora cavernosa clitoridis, having accompanied the dorsal vein of the clitoris, also terminate in the internal iliac glands.

The **pudic nerve** and its branches are similar to those in the male, the superficial perineal nerves being distributed to the labia majora.

ABDOMINAL WALL.

Landmarks.—The position of the **linea alba** is indicated by the mid-abdominal groove, which extends from the ensiform process of the sternum to the umbilicus, and the mid-abdominal line, which extends from the umbilicus to the upper part of the symphysis pubis. After removal of the integument the linea alba presents a dense white appearance, and is slightly depressed below the level of the adjacent surfaces. It is produced by the decussation of the aponeuroses of the abdominal muscles of opposite sides, except the recti, and it is divided into two parts, supra-umbilical and infra-umbilical. The supra-umbilical part is about $\frac{1}{4}$ inch broad, the recti being here separated to that extent. The infra-umbilical part is only about $\frac{1}{8}$ inch wide on account of the approximation of the recti in this situation. Over the whole extent of its posterior or abdominal surface it is invested by the parietal peritoneum, unless in cases of abnormal distension of the bladder, when the peritoneum is stripped from the lower part to an extent corresponding with the height to which the distended bladder ascends. The anterior abdominal wall is thinner and less vascular along the linea alba than at any other part. This line is therefore selected for such operations as suprapubic lithotomy, tapping a distended bladder above the symphysis pubis, and ovariotomy.

The structures which are divided in opening the abdominal cavity along the linea alba are as follows: the integument, the decussating fibres of the aponeuroses of opposite sides, fascia transversalis, subperitoneal areolar tissue, and parietal peritoneum. There are no bloodvessels of any importance in this situation.

The posterior aspect of the linea alba has important visceral relations. The left lobe of the liver lies behind it for about 2 inches below the ensiform process of the sternum. The relation of the stomach to it is variable. When the viscus is moderately distended it lies behind the linea alba below the margin of the liver. In the empty condition, however, it recedes from the linea alba, and this gives rise superficially to the *epigastric depression*, or *scrobiculus cordis* ('small trench of the heart'). The transverse colon, covered by the great omentum, as it crosses from right to left, usually lies behind the linea alba just above the umbilicus. The coils of the jejunum and ileum, also covered by the great omentum, lie behind it below the umbilicus.

In young persons the upper part of the bladder, being extra-pelvic, lies behind the lowest part of the linea alba. In adults the upper part of that viscus, when abnormally distended, also lies behind the lowest part of this line.

The **umbilicus** takes the form of a cicatricial depression which is situated in the linea alba at the junction of the upper three-fifths and lower two-fifths. As seen from before it is irregularly circular, the skin being more or less puckered according to the state of distension of the abdomen. When viewed from behind it is smaller in size, and its long measurement lies transversely. Besides cicatricial tissue and fat, the lower part of it contains the upper ends of the urachus and obliterated hypogastric arteries, whilst the upper part is occupied by part of the obliterated umbilical vein. The upper part is weaker than the lower. The umbilicus is on the same horizonal plane as the disc between the bodies of the third and fourth lumbar vertebræ.

During intra-uterine life the umbilicus is an opening by which the hypogastric arteries leave the abdomen of the fœtus on their way to the placenta, and by which the umbilical vein, on its way from the placenta, enters the abdomen. A few days after birth, however, the opening becomes permanently closed.

The **lineæ semilunares** coincide with the outer borders of the recti abdominis. The position of each is indicated by a line drawn from the lowest part of the eighth costal cartilage to the pubic spine. This line is curved, with the convexity outwards, and at the level of the umbilicus it is about 3 inches from it. Over the upper three-fourths of the rectus abdominis it indicates the splitting of the aponeurosis of the internal oblique into two laminæ, which encase that extent of the muscle in a sheath. Over the lower fourth it indicates where the aponeuroses of the external oblique and internal oblique and the anterior aponeurosis of the transversalis abdominis pass in front of the rectus.

The **lineæ transversæ** are usually three in number, on either side. They are tendinous intersections or inscriptions which cross the rectus in the following situations: one at the level of the umbilicus, one at the level of the lower part of the ensiform process of the sternum, and one about midway between these two. The positions of the lineæ transversæ are indicated by three faint grooves. The anterior wall of the sheath of the rectus is closely bound down to the tendinous intersections, and so each muscle above the level of the umbilicus is mapped out into two quadrangular areas, and the interior of the sheath, anterior to the muscle, is also divided into two distinct compartments. An abscess may form in one or other of these compartments, or there may be a spasmodic contraction of one or other of these quadrangular areas of the muscle, a condition in each case which would necessarily have a circumscribed limit, and might lead to error in diagnosing affections really having their seat within the abdominal cavity.

The **spino-umbilical lines** are two in number, right and left,

and each extends from the anterior superior iliac spine to the umbilicus.

The **anterior superior spinous process of the ilium** is situated at the anterior extremity of the iliac crest, and, being very superficial, it can be readily felt. It is on the same level with that of the opposite side, and therefore a line connecting the two should be quite horizontal. The plane of this interspinous line is rather lower than the promontory of the sacrum. The anterior superior iliac spine is the point from which the measurement of the lower limb is taken, the other point being the internal malleolus. This spine is also a good ready guide to the position of the great trochanter, which is situated about 4 inches below it, and about 4½ inches behind a line let fall vertically from it.

The **pubic spine** is situated at the lower and inner part of the anterior abdominal wall about 1½ inches outside the upper part of the symphysis pubis. It is sometimes a sharp-pointed process, and then it can readily be felt beneath the integument. In most persons, however, it takes the form of a more or less indistinct tubercle, and cannot readily be made out. In such cases the scrotal integument may be invaginated with the finger, and so the adipose tissue raised from over the spine. If it cannot be felt in this way the thigh should be well abducted to render prominent the adductor longus muscle, the tendon of origin of which will serve as a guide to the spine, which lies above and to the outer side of it. The pubic spine is the guide to the external abdominal ring, the crural or femoral ring, and the saphenous opening. The **external abdominal ring** is situated immediately above, and to the outer side of, the pubic spine. In exploring the ring the best way to proceed is to invaginate the scrotal integument, and carry the examining finger up the inner side of the spermatic cord, when the ring will be reached. In normal circumstances it should admit the point of the little finger. In making this examination the spermatic cord is readily felt, and the vas deferens can be distinguished as a firm cord-like structure lying at its back part, and easily separable from the other constituents of the cord. In the female the round ligament of the uterus takes the place of the spermatic cord, but, being a very ill-defined structure, it usually escapes detection. The **crural** or **femoral ring** is situated fully 1 inch external to the pubic spine in a line drawn transversely outwards from that spine across the front of the thigh. The **saphenous opening** is situated below, and a little external to, the pubic spine.

The **pubic crest** extends transversely inwards for about 1¼ inches from the pubic spine, and it terminates in the pubic angle which surmounts the internal surface of the pubic body, and is usually a rudimentary tubercle. The crest may be felt with the finger as the external abdominal ring, of which it forms the base, is being explored.

Poupart's ligament can be felt as a tense band, especially when the thigh is extended, abducted, and rotated outwards,

passing between the anterior superior iliac spine and the pubic spine.

The **internal abdominal ring** is situated midway between the symphysis pubis and the anterior superior iliac spine, and ½ inch above Poupart's ligament.

The **inguinal canal** extends obliquely downwards, forwards, and inwards from the internal to the external abdominal ring, and is situated immediately above the inner half of Poupart's ligament.

Topography of Arteries, Triangles, and Iliac Fossæ.—The **bifurcation of the aorta** into right and left common iliac arteries usually takes place opposite the centre of the body of the fourth lumbar vertebra, a finger's breadth to the left of the middle line. The position of the bifurcation is indicated in one of two ways: (1) a point fully 1 inch below the umbilicus and a finger's breadth to the left of the linea alba pretty nearly corresponds with the point of bifurcation; (2) a more definite guide is a point in the line which connects the highest parts of the iliac crests a finger's breadth to the left of where it intersects the linea alba.

The **common and external iliac arteries** are indicated by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the point corresponding to the bifurcation of the aorta. This line should be slightly curved, with the convexity directed outwards. Its upper 2 inches indicate the course of the common iliac artery, and the remainder represents the external iliac.

The **deep epigastric artery,** in its first or oblique part, is indicated by a line drawn from the inner border of the internal abdominal ring to the outer border of the rectus abdominis at a point midway between the upper border of the symphysis pubis and the umbilicus. The subsequent course of the vessel is represented by a line corresponding to the centre of the rectus abdominis, and reaching to a point about 2 inches above the umbilicus. This latter line is about 1½ inches distant from the linea alba.

The **triangle of Hesselbach** is situated on the inner side of the first or oblique part of the deep epigastric artery, and above the inner half of Poupart's ligament.

The **triangle of Petit** is situated immediately above the centre of the iliac crest. In this region a lumbar hernia may protrude, and a lumbar abscess may come to the surface at this point.

The **right iliac fossa** contains the terminal part of the ileum, the cæcum, the ileo-cæcal valve, and the vermiform appendix in part.

The **left iliac fossa** contains the iliac colon.

McBurney's point is situated in the right spino-umbilical line between 1½ and 2 inches from the anterior superior iliac spine. According to McBurney it corresponds very accurately in the living subject to the base of the vermiform appendix. Practically it coincides with the centre of the right iliac fossa.

Monro's point is situated at the centre of the spino-umbilical line. Its distance from the anterior superior iliac spine is 2·6 inches.

Upon the right side McBurney's point and Monro's point very nearly coincide. Both of these points are now regarded as indicating approximately the situation of the ileo-cæcal valve, and not the base of the vermiform appendix. The guide to the base or opening of the appendix is a point on an average rather more than 1 inch below the ileo-cæcal valve—that is to say, the base or opening of the vermiform appendix is rather more than 1 inch below McBurney's point.*

Anterior Abdominal Fasciæ.—The **superficial fascia** of the anterior wall of the abdomen, from Poupart's ligament to a line drawn transversely from the anterior superior iliac spine to the linea alba, resembles the superficial fascia of the uro-genital division of the perineum in being divisible into two layers. The layer immediately beneath the skin is called the subcutaneous layer or fascia of Camper, and the other layer is called the deep layer or fascia of Scarpa.

The *subcutaneous layer* or **fascia of Camper** is composed of areolar tissue containing adipose tissue in its meshes. When traced upwards it blends with the deep layer above the level of the line connecting the anterior superior iliac spine with the linea alba. When followed inwards it is continuous with the corresponding layer of the opposite side. In a downward direction it is freely continuous over Poupart's ligament with the subcutaneous layer of the superficial fascia of the front of the thigh. When traced downwards and inwards it passes along the spermatic cord into the scrotal wall and over the penis, in which situations, more especially the former, it contains involuntary muscular fibres, which replace its adipose tissue, and so, with the deep layer which it here joins, it forms the *tunica dartos*. In the female Camper's fascia passes along the round ligament of the uterus into the labium majus.

The *deep layer* or **fascia of Scarpa** is a strong membrane which contains yellow elastic tissue. It is separated from Camper's fascia by the superficial epigastric vessels, and, in the region of Poupart's ligament, by the inguinal glands. Its deep aspect is loosely connected by areolar tissue to the subjacent aponeurosis of the external oblique muscle. Superiorly, above the line connecting the anterior superior iliac spine with the linea alba, it blends with Camper's fascia. At the middle line it is firmly bound down by fibrous bands to the linea alba. Inferiorly it blends with the inner part of Poupart's ligament, but external to this it passes over that ligament, to which it is bound by fibrous bands, and immediately thereafter it becomes incorporated with the fascia lata of the thigh. When traced downwards and inwards it passes along the spermatic cord into the scrotal wall, and over the penis. In the former situation it forms, along with the subcutaneous layer, the *tunica dartos*. In the female Scarpa's

* Sir Frederick Treves, based upon observations made by Dr. C. Addison and Dr. Arthur Keith.

fascia passes along the round ligament of the uterus into the labium majus.

The fascia of Camper is continuous, through the tunica dartos, with the subcutaneous layer of the superficial fascia of the uro-

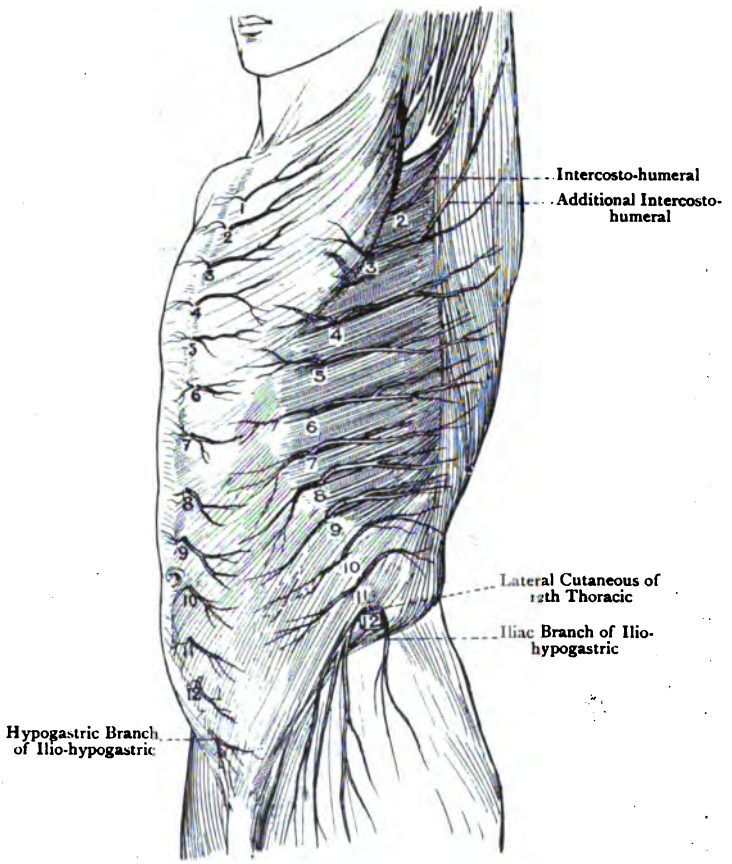


FIG. 273.—CUTANEOUS NERVES OF THE TRUNK (ANTERO-LATERAL VIEW) (AFTER HENLE).

1-12, Anterior Cutaneous; 2-12, Lateral Cutaneous.

genital division of the perineum, and the fascia of Scarpa is similarly continuous with the deep layer of the superficial fascia, or the fascia of Colles, of that division.

The disposition of Scarpa's fascia at the line of the groin explains why, in cases of extravasation of urine beneath Colles's fascia, the urine, when it reaches the anterior abdominal wall, does not pass

downwards to the front of the thigh, but takes an upward course.

The fascia of Scarpa represents the *tunica abdominalis* of quadrupeds, which is composed almost entirely of yellow elastic tissue, and serves as an important adjunct to the abdominal parietes.

The **deep fascia** resembles that in other parts of the body in being membranous. Laterally, where the external oblique is fleshy, this fascia is well marked, but, as it approaches the confines of the aponeurosis of that muscle, it becomes very delicate, and ultimately disappears. Over the external oblique aponeurosis, therefore, there is really no deep fascia properly so called, so that the deep layer of the superficial fascia or fascia of Scarpa lies directly upon the external oblique aponeurosis, to which it is loosely connected by areolar tissue.

Cutaneous Nerves. — The **anterior cutaneous nerves** are the terminal branches of the lower five intercostal nerves and of the anterior primary division of the twelfth thoracic nerve (subcostal nerve). Having emerged through the anterior wall of the sheath of the rectus abdominis in a straggling manner, they give a few twigs inwards, and then turn outwards to supply the anterior abdominal integument, in which they communicate with the anterior branches of the lateral cutaneous nerves.

The **hypogastric branch of ilio-hypogastric nerve** pierces the external oblique aponeurosis about 1 inch above the external abdominal ring, and is distributed to the integument of the supra-pubic region. It is serially continuous with the anterior cutaneous nerves.

The skin below the ensiform process is supplied by the seventh thoracic nerve; that on a level with the umbilicus by the tenth thoracic; and that over the lower half of the infra-umbilical region by the twelfth thoracic, and the ilio-hypogastric.

The **lateral cutaneous nerves** are branches of the lower five intercostal nerves. Having emerged between the serrations of the external oblique muscle in the mid-axillary line, each divides into an anterior and a posterior branch. The *posterior branch* turns backwards to supply the integument over the lower part of the back. The *anterior branch* passes forwards to supply the anterior abdominal integument, in which it communicates with an anterior cutaneous nerve.

Cutaneous Arteries.—The **superior or superficial external pudic artery** arises from the common femoral about ¾ inch below Poupart's ligament, after which it pierces the crural sheath and cribriform fascia. Having emerged through the saphenous opening, it passes inwards and upwards over the spermatic cord, or round ligament of the uterus, according to the sex, to be distributed to the integument of the suprapubic region, the adjacent portion of the scrotum in the male and the labium majus in the female, and the dorsum of the penis by a branch which extends as far as the prepuce, lying external to the dorsalis penis artery. The vessel in its course gives branches to the pubic glands, the deep femoral glands, and the coverings of the spermatic cord, or of the round ligament of the uterus. It anasto-

moses with the following arteries: (*a*) the cremasteric branch of the deep epigastric, in crossing the spermatic cord, that branch being represented in the female by the artery of the round ligament of the uterus; (*b*) its fellow of the opposite side; (*c*) the inferior or deep external pudic; and (*d*) the dorsalis penis.

The venæ comites of this artery terminate in one vessel which joins the long saphenous vein.

The **superficial epigastric artery** arises from the common femoral about ½ inch below Poupart's ligament. Having pierced the crural sheath and cribriform fascia, or the outer border of the saphenous opening, it turns upwards over Poupart's ligament a little to the inner side of the centre, and then ascends in the abdominal integument as high as the level of the umbilicus. As it turns upwards it supplies branches to the inguinal glands, and on the abdominal wall it anastomoses with branches of the deep epigastric artery.

There are at first two venæ comites with this artery, but these eventually join to form one vessel which terminates in the long saphenous vein. The radicles of these venæ comites communicate with the following vessels: the parumbilical veins in the region of the umbilicus, which lie on the surface of the round ligament of the liver, and communicate with the branches of the vena portæ; the inferior or long thoracic and subscapular veins, upon the side of the thorax, which are tributaries of the axillary vein; and the superior epigastric veins, which are tributaries of the internal mammary veins. In the superficial epigastric vein and its tributaries the blood can flow in either direction. The anastomoses of the tributaries of the vein explain why they become engorged in cases of portal obstruction and obstruction of the inferior vena cava.

The **superficial circumflex iliac artery** often arises in common with the superficial epigastric from the common femoral about ½ inch below Poupart's ligament. Having pierced the crural sheath and the outer border of the saphenous opening, it passes outwards below the outer part of Poupart's ligament to the anterior part of the iliac crest, where it is distributed to the adjacent abdominal integument. In its course it gives branches to the iliacus and sartorius muscles and the outer inguinal glands, and it anastomoses with (*a*) the deep circumflex iliac of the external iliac, and (*b*) the gluteal of the internal iliac.

The vein corresponding to this artery terminates in the long saphenous vein.

The **anterior cutaneous arteries** are derived from the deep and superior epigastric arteries. They emerge through the anterior wall of the sheath of the rectus abdominis in an irregular manner, and accompany more or less closely the anterior cutaneous nerves.

The veins corresponding to these arteries terminate in the deep and superior epigastric veins.

The **lateral cutaneous arteries** are branches of the lower five aortic intercostal and subcostal arteries, and they emerge with the lateral cutaneous nerves between the serrations of the external oblique muscle in the mid-axillary line.

The veins corresponding to these arteries are tributaries of the lower five intercostal and subcostal veins.

Superficial Lymphatics.—The superficial lymphatics *below* the level of the umbilicus accompany the superficial epigastric vessels, and terminate in the inguinal glands. Those *above* the level of the umbilicus pass to the axillary glands. The superficial lymphatics of the *lateral* abdominal wall terminate in two ways. Some accompany the superficial circumflex iliac vessels, and terminate in the inguinal glands; others accompany the abdominal branches of the lumbar arteries, and terminate in the deeply-placed lateral group

of lumbar glands. For the deep lymphatics of the antero-lateral abdominal wall, see p. 625.

Penis. Coverings.—The **skin** at the free extremity of the glans, being doubled upon itself, passes backwards until it reaches the constriction behind the corona glandis called the cervix. Here it is reflected forwards, closely investing the cervix, corona glandis, and body of the glans. On reaching the lips of the meatus urinarius it becomes continuous with the mucous membrane of the urethra. The skin covering the glans is provided with papillæ, but these do not appear on the surface. The duplicature, which the skin forms in the region of the glans, is called the *præputium penis*, or prepuce. The under part of the prepuce is connected to the under surface of the glans by a median, laterally compressed, triangular fold, called the *frenum præputii*, which extends as far as the lower part of the meatus urinarius. The skin of the cervix, corona glandis, and adjacent part of the inner surface of the prepuce contains large sebaceous glands, called the *glands of Tyson*. Their secretion is a whitish curdy substance, and is strongly odorous, from which character the glands have been called the *glandulæ odoriferæ*, the secretion being called the *smegma præputii* (unguent of the prepuce). The **dartos tunic** is situated immediately beneath the skin, and is destitute of adipose tissue. It is continuous with Camper's and Scarpa's fasciæ of the anterior abdominal wall, and with the tunica dartos of the scrotum, like which latter it contains involuntary muscular tissue. The **fascial investment** or **sheath** covers the penis, with the exception of the glans. It is situated beneath the dartos tunic, and at the cervix blends with the skin of the glans. Towards the root of the organ it receives expansions from the ischio-cavernosi and bulbo-cavernosi, and it covers the dorsal vessels and nerves. In this way the dorsal vein is compressed during the action of the ischio-cavernosi and bulbo-cavernosi. At the root of the organ the fascial investment blends with the two layers of the suspensory ligament.

Suspensory Ligament.—This ligament, which is strong and triangular, is composed of fibrous and elastic tissues. It is attached superiorly to the front of the symphysis pubis, where it is single, and inferiorly it divides into two laterally-disposed, diverging laminæ, which blend with the fascial sheath of the penis. The interval between the two laminæ is occupied by the dorsal vessels and nerves.

The **dorsal arteries.**—For the description of these arteries, see p. 588.

In addition to the dorsal arteries, the integument of the organ is supplied by the superior or superficial external pudic arteries, the branch from each of these vessels lying external to the dorsalis penis artery.

Dorsal Vein.—The tributaries which give rise to this vein come from the glans and prepuce. They form at first two dorsal veins, but these soon unite into one vessel, which passes backwards in the middle line, occupying the groove between the corpora

cavernosa, where it is under cover of the fascial sheath of the penis. At the root of the organ it passes between the two laminæ of the suspensory ligament, and then between the subpubic and transverse perineal or pelvic ligaments. In this part of its course it communicates with the venous plexus in the compressor urethræ muscle in which the internal pudic venæ comites arise. On entering the pelvis it divides into two branches, which terminate in the right and left portions of the prostatic plexus of veins.

For a description of the dorsal nerves of the penis, see p. 591.

The relation of the structures on the dorsum of the penis, from the middle line outwards, is as follows: dorsal vein, dorsal artery, and dorsal nerve.

Composition of the Penis.—The penis has two surfaces, upper or dorsal and under or scrotal. Viewed as a whole the organ is composed of three cylindrical bodies, namely, two corpora cavernosa and a corpus spongiosum, closely applied to each other. It is divisible into a root, body, cervix, and glans. The **root** is formed by the crura of the corpora cavernosa, which are attached to the inner margins of the ischio-pubic rami. The upper surface of the root is also connected to the symphysis pubis by the suspensory ligament. The upper or dorsal surface of the **body** is formed by the corpora cavernosa, the under or scrotal surface being formed by the corpus spongiosum in the middle line and the corpora cavernosa at either side. The corpora cavernosa and corpus spongiosum at their meeting become flattened, and so the shape of the body is subcylindrical. The corpora cavernosa terminate in round extremities, in front of which the corpus spongiosum turns upwards, and, becoming much enlarged, forms the glans penis. The **cervix** is the constriction between the body and the glans. The **glans penis** is formed by the corpus spongiosum. It is somewhat conical, and has been likened to an acorn, from which circumstance it has been called the *balanus*. At the base there is a wheel-like rim, called the *corona glandis*. The part anterior to the corona is called the body of the glans, and this terminates in a small round tip, which presents a vertical fissure called the *meatus urinarius*. For the structure of the penis, see p. 813.

Lymphatics.—These are divided into a superficial and deep set.

The **superficial lymphatics** of the prepuce, having formed a plexus, pass to the cervix, which they surround in the form of a ring. Those of the glans, having also formed a plexus, pass along with those of the spongy portion of the urethra to the foregoing ring. From this ring three lymphatic trunks proceed towards the symphysis pubis. One of these is median and dorsally placed, whilst the other two are disposed one on either side. The median trunk, when it reaches the suspensory ligament of the penis, divides into two branches, right and left. Each of these passes with the corresponding lateral trunk to the groin of the same side, where both terminate in the *pubic group* of the *inguinal glands*. The position of the foregoing three lymphatic trunks

accounts for the red lines which are often seen along the dorsum and sides of the penis when septic matter is absorbed from a venereal sore on the prepuce or glans. Their mode of termination also explains the occurrence of induration, or of suppuration, in the inguinal glands as the result of such sores, or of gonorrhœa.

The **deep lymphatics** return the lymph from the substance of the penis, and accompany the dorsalis penis vein into the pelvis, where they terminate in the *internal iliac glands*.

The lymphatics of the clitoris correspond with those of the penis.

Scrotum.—The wall of the scrotum is complex, and its constituent parts will be made more evident if they are enumerated in the order in which the testes receive them in their original descent from the abdominal cavity. It may be premised that the descent of each testis is preceded by a process of peritoneum, called the processus vaginalis, the lower part of which remains permanent as the tunica vaginalis scroti. The constituent parts of the scrotal wall, enumerated from within outwards, are as follows: tunica vaginalis scroti, subperitoneal areolar tissue, internal spermatic fascia, cremasteric or middle spermatic fascia, intercolumnar or external spermatic fascia, tunica dartos, and skin.

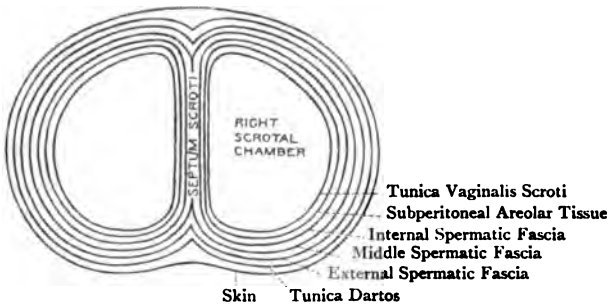


FIG. 274.—SCHEME OF THE STRUCTURES FORMING THE WALL OF THE SCROTUM (TRANSVERSE SECTION).

The **tunica vaginalis scroti** is the parietal layer of the tunica vaginalis.

The **subperitoneal areolar tissue** is composed of areolar and adipose tissues, and a certain amount of plain muscular tissue, its muscular element being known as the **middle cremaster.**

The **internal spermatic fascia** is derived from the fascia transversalis at the margins of the internal abdominal ring, in which vicinity it is called the **infundibuliform fascia.** In association with the subperitoneal areolar tissue it forms the *fascia propria* of Cooper.

The **cremasteric,** or **middle spermatic, fascia** is composed of striated muscular tissue, forming the cremaster muscle (external cremaster), and of areolar and elastic tissues. It is traceable superiorly to the lower border of the internal oblique and the centre of Poupart's ligament on its deep aspect.

The **intercolumnar,** or **external spermatic, fascia** is composed of connective tissue, and is derived from the intercolumnar fibres which extend between the columns of the external abdominal ring. The internal, middle, and external spermatic fasciæ are closely incorporated with one another.

The **tunica dartos** lies immediately within the skin. It is derived from the fasciæ of Camper and of Scarpa of the anterior abdominal wall. It is chiefly composed of plain muscular tissue, but it also contains fibro-areolar and elastic tissues, and it has a brick-red colour.

The **skin** is thin, very extensible, somewhat dark in colour, and provided with hairs, sweat-glands, and sebaceous glands. It is more dependent on the left side on account of the lower position of the left testis. In the middle line it presents a raphé, which is continuous behind with that of the anterior part of the perineum, and in front with that on the under surface of the penis. This raphé is an external indication of the bilateral symmetry of the scrotum. On either side of the raphé the skin is thrown into a number of transverse rugæ, the corrugated condition being due to the plain muscular tissue of the tunica dartos.

The interior of the scrotum is divided into two compartments, each of which lodges the corresponding testis. This division is effected by the **septum scroti**, formed by the fusion of the contiguous walls of the two scrotal chambers, except the skin, which forms one continuous investment to both. Inferiorly the septum is attached to the bottom of the scrotal chamber, and superiorly to the under surface of the root of the penis.

Blood-supply.—The scrotum receives its chief arterial supply from the superior and inferior external pudic branches of the common femoral of each side, and the superficial perineal branches of the internal pudic arteries.

The **veins** corresponding to these arteries terminate in the long saphenous and internal pudic veins.

The cremasteric branch of the deep epigastric of each side also takes part in the supply of the scrotal wall, the venous blood being returned into the deep epigastric vein, which at its termination is single.

Lymphatics.—The most of the lymphatics of the scrotum terminate in the *inner inguinal glands*, but those from the back part pass to the *internal iliac glands*.

Nerve-supply.—The nerves of the scrotum are as follows: (1) the external or posterior and internal or anterior superficial perineal branches of the pudic; (2) the long pudendal nerve of Sœmmering from the small sciatic; (3) the inguinal nerve (ilio-inguinal) from the lumbar plexus; and (4) twigs of the genital branch of the genito-crural nerve from the lumbar plexus. The two superficial perineal nerves and the long pudendal nerve are known as the **long scrotal nerves.**

Muscles of Abdominal Wall. Obliquus Externus Abdominis—*Origin.*—The outer surfaces of the lower eight ribs by means of eight fleshy slips, the upper five of which interdigitate with slips of the serratus magnus, and the lower three with slips of the latissimus dorsi.

Insertion.—(1) The anterior half of the outer lip of the iliac crest by fleshy fibres. (2) By means of an aponeurosis into (*a*) the linea alba; (*b*) the pubic spine and crest of the opposite side through means of the triangular fascia; (*c*) the front of the symphysis pubis; (*d*) the pubic spine of the same side; (*e*) the first inch

of the ilio-pectineal line; and (*f*) the anterior superior iliac spine.

Nerve-supply.—The lower five intercostal nerves and the subcostal nerve.

Action.—(1) The two muscles, acting conjointly, diminish the size of the abdominal cavity, and so compress the viscera, as in defæcation. (2) The two muscles, acting conjointly from their origins, raise the front part of the pelvis and flex it upon the thorax. (3) Acting conjointly from their insertions, they flex the thorax upon the pelvis, the vertebral column being also flexed in the lower thoracic and lumbar regions; but, if the column is fixed, the two muscles depress the lower eight ribs. (4) One muscle, acting from its origin, is a lateral flexor of the pelvis. When it acts from its insertion it flexes the thorax towards its own side and rotates it to the opposite side.

The most of the fibres of the external oblique pass downwards and forwards, coinciding in direction with those of the external intercostal muscles. The only parts of the muscle which are free are the part between the last rib and the iliac crest, and the part opposite the pubic crest. The aponeurosis attains its greatest width and strength at, and below, the level of the anterior superior iliac spine, and it is narrowest opposite the umbilicus. Superiorly it gives origin to fibres of the pectoralis major. Crossing the fibres of the aponeurosis in an upward and inward direction there are several superadded fibres. In the lower part of the abdominal wall these are specially well marked, and are here spoken of as the **intercolumnar fibres.** Under this name they spring from the outer third of Poupart's ligament, whence they pass upwards and inwards in a curved manner, the convexity being downwards. On arriving at the upper and outer part of the external abdominal ring they extend from one column to the other. They round off and close the ring, and are prolonged upon the spermatic cord to form the *intercolumnar* or *external spermatic fascia.*

The following parts of the external oblique aponeurosis require special description: Poupart's ligament, Gimbernat's ligament, the triangular fascia, the external abdominal ring, and the linea alba.

Poupart's ligament, also known as the **superficial crural arch,** is the thickened lower border of the external oblique aponeurosis, which is folded backwards. Externally it is attached to the anterior superior iliac spine, and internally to the pubic spine, from which it is reflected outwards and backwards upon the ilio-pectineal line for fully 1 inch to form Gimbernat's ligament. The ligament is curved, the convexity being directed downwards and outwards, which is due to the attachment of the iliac lamina of the fascia lata to its lower border. The convexity is greatest when the thigh is extended, abducted, and rotated outwards, in which position the fascia lata on the front of the thigh is tightened.

Relations—*Superficial.*—Skin; Camper's and Scarpa's fasciæ; superficial epigastric vessels, a little to the inner side of the centre; superficial circumflex iliac vessels just below its outer part; and the inguinal

glands along its lower border. *Deep.*—Internal oblique along the outer half, and transversalis abdominis along the outer third. Along the outer half the fascia transversalis and fascia iliaca are attached, and form a canal containing the deep circumflex iliac vessels. The fascia transversalis continues to be attached to the inner part, but loosely and only as far inwards as the base of Gimbernat's ligament. The deep crural arch is also a deep

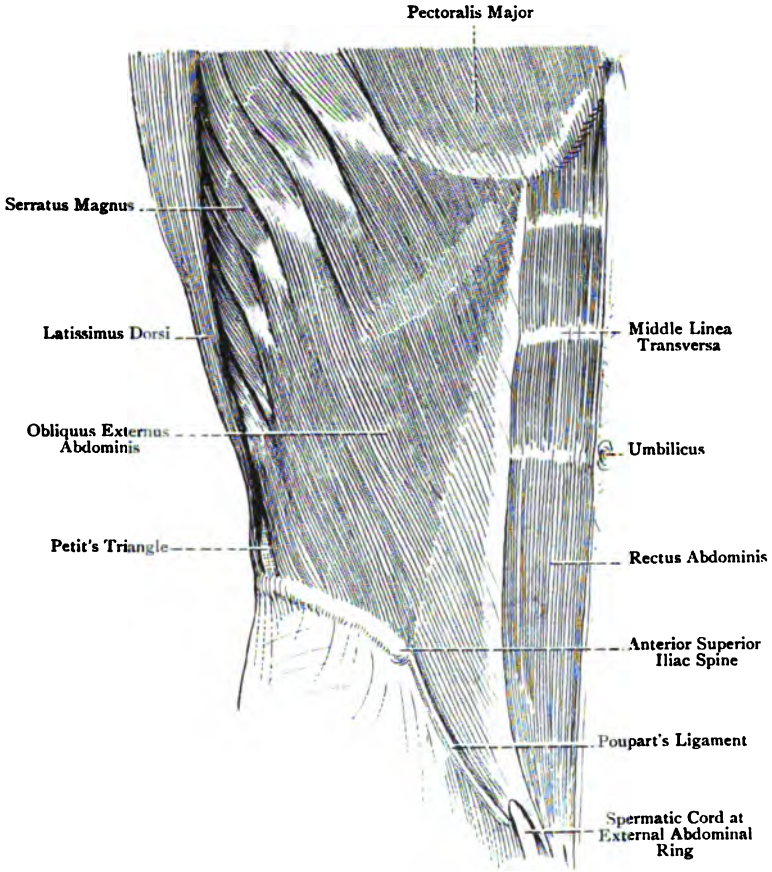


FIG. 275.—THE EXTERNAL OBLIQUE MUSCLE.

relation. Poupart's ligament, along with the irregularly concave border of the os innominatum, forms a large fibro-osseous canal. This region is known as the *lacunar region.*

The **deep crural arch** is a thickening of the fascia transversalis as it passes downwards beneath Poupart's ligament to form the anterior wall of the crural sheath. The thickening is due to superadded fibres which extend inwards from the centre of Poupart's ligament on its deep aspect to the ilio-pectineal line, where they are attached behind Gimbernat's ligament near its base.

Gimbernat's ligament is the reflection of Poupart's ligament from the pubic spine along the ilio-pectineal line. Its length is fully 1 inch, and it is triangular, the apex being at the pubic spine. It presents three borders and two surfaces. Two of the borders are fixed, one, called the *Poupart border*, being continuous with the inner end of Poupart's ligament, and the other, called the *pectineal border*, being implanted on the pectineal portion of the ilio-pectineal line. The third border is free, and is called the **base.** It is sharp, wiry, and concave, and is situated immediately to the inner side of the crural or femoral ring. The surfaces of the ligament are femoral and abdominal. They occupy an oblique plane, the *femoral surface* looking downwards, forwards, and slightly outwards, whilst the *abdominal surface* looks upwards, backwards, and slightly inwards. This latter surface, along its line of junction with Poupart's ligament, forms the floor of the inguinal canal in its lower third, where it supports the spermatic cord in the male, and the round ligament of the uterus in the female. The fascia transversalis takes attachment to the base of the ligament on its abdominal aspect, and the conjoined tendon and fascia transversalis are behind it at the ilio-pectineal line. A few of the fibres of the superior cornu of the saphenous opening terminate on the femoral surface of the ligament, and the pectineus muscle and pubic lamina of the fascia lata are in front of its pectineal attachment.

The **triangular fascia**, also known as the *ligament of Colles*, is situated behind the spermatic cord and internal pillar of the external abdominal ring. Its fibres are derived from the external oblique aponeurosis of the opposite side, and, having crossed the linea alba, they take insertion into the pubic spine and crest. A portion of the fascia is seen lying in the lower and inner part of the external abdominal ring.

The **external abdominal ring** is an opening in the aponeurosis of the external oblique, and it is situated immediately above, and to the outer side of, the pubic spine. It serves for the passage of the spermatic cord in the male, and the round ligament of the uterus in the female. In the natural condition no opening is perceptible, the intercolumnar fibres rounding it off, and being prolonged downwards upon the transmitted structure. When the intercolumnar fibres and fascia have been removed, the ring is seen to be formed in the following manner: the fibres of the external oblique aponeurosis, as they approach the os pubis, are disposed in two diverging bundles. One bundle, which represents the inner end of Poupart's ligament, is fixed to the pubic spine. The other bundle passes to be attached to the front of the symphysis pubis, where its fibres decussate with those of its fellow of the opposite side, the fibres from the right side being superficially placed. An interval is thus left between these diverging bundles, which is widest at the lower and inner part, where it corresponds with a portion of the pubic crest. This interval is the external abdominal ring. Its direction is upwards and outwards, and

it is parallel with the inner part of Poupart's ligament. Its length is from 1 inch to 1½ inches, and its breadth at the base about ½ inch. It is triangular, the base being formed by part of the pubic crest, and the apex being directed upwards and outwards. The margins of the ring are called pillars or columns. From the oblique position of the ring one pillar is external and inferior, the other being internal and superior. The *internal* or *superior pillar*, which is thin and straight, passes to be attached to the front of the symphysis pubis. The *external* or *inferior pillar* is at first thin, but it soon becomes thick and prismatic, and is fixed to the pubic spine. It presents superiorly a concavity which lodges the spermatic cord in the male and the round ligament of the uterus in the female. The intercolumnar or external spermatic fascia is attached to both pillars, and it here lies upon the spermatic cord. Underneath the cord this fascia is attached along the pubic crest between the pillars of the ring. These attachments of the fascia explain why urine, extravasated into the perineum, does not find its way into the inguinal canal. Within the lower and inner part of the ring is the triangular fascia, and directly behind the ring is the conjoined tendon, which strengthens what would otherwise be a weak part of the abdominal wall. The ring is smaller in the female than in the male.

The **linea alba** has been already described (see p. 600).

The **triangle of Petit** is only present when the latissimus dorsi and external oblique do not meet. It is situated immediately above the centre of the iliac crest, and is bounded *in front* by the posterior border of the external oblique, *behind* by the anterior border of the latissimus dorsi, and *below* by the central portion of the iliac crest. It is covered only by skin and fascia, and its *floor* is formed by a part of the internal oblique. In this situation a lumbar hernia may occur, or a lumbar abscess may find its way to the surface.

Obliquus Internus Abdominis—*Origin.*—(1) The deep or abdominal surface of Poupart's ligament over its outer half; (2) the summit of the iliac crest over its anterior two-thirds; and (3) the *posterior* aponeurosis of the transversalis abdominis.

Insertion.—(1) The lower borders of the cartilages of the lower three or four ribs; (2) the lower borders of the cartilages of the seventh and eighth ribs, and the side of the ensiform process of the sternum; (3) the linea alba in its whole length; (4) the front of the pubic crest; and (5) the pectineal portion of the ilio-pectineal line for ½ inch.

Nerve-supply.—This is similar to that of the external oblique, with the addition of twigs from the inguinal nerve and hypogastric branch of the ilio-hypogastric, both of which are derived from the lumbar plexus, more particularly the first lumbar nerve.

Action.—This is similar to that of the external oblique. When the right internal oblique acts simultaneously with the left external oblique, the trunk is rotated to the right side, and *vice versâ*. To

understand this action, it is to be noted that the fibres of the internal oblique of one side coincide in direction with those of the external oblique of the opposite side.

The most of the fibres pass upwards and forwards across those of the external oblique, and coinciding with those of the internal intercostal muscles. The Poupart fibres, however, pass downwards and inwards, and join the corresponding fibres of the transversalis

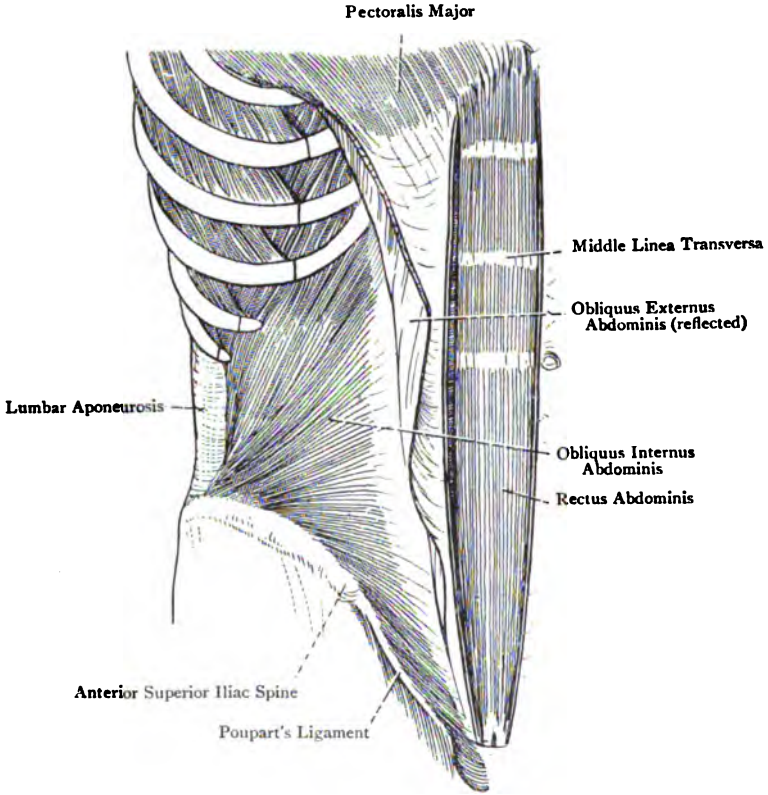


FIG. 276.—THE INTERNAL OBLIQUE MUSCLE.

abdominis to form the conjoined tendon. The aponeurosis is broader above than below. Along the outer border of the rectus abdominis, over about its upper three-fourths, it divides into two laminæ, one of which passes in front of the muscle and the other behind it. The anterior lamina joins the aponeurosis of the external oblique, and the posterior lamina joins the *anterior* aponeurosis of the transversalis abdominis. It is this latter lamina which has an insertion into the seventh and eighth costal cartilages and ensiform

process. Over about the lower fourth of the rectus the aponeurosis remains single, and passes in front of the muscle. The Poupart fibres of the muscle, as they leave the ligament, are in front of the spermatic cord as it lies in the upper third of the inguinal canal. They then arch over it, and finally descend behind it as it lies in the lower two-thirds of the inguinal canal. In this latter situation the fibres have terminated in the conjoined tendon.

Cremaster—*Origin.*—The deep aspect of Poupart's ligament in its inner part. A few fibres are also derived from the lower border of the internal oblique. The fibres descend in a series of loops upon the outer and anterior aspects of the spermatic cord. The lowest loops reach the tunica vaginalis of the testis, upon the upper part of which they spread out in an arched manner, some of the fibres terminating on it. The other loops are successively shorter from below upwards, and ascend on the inner and posterior aspects of the cord, where they become tendinous and indefinite, to take *insertion* into the pubic spine and anterior lip of the pubic crest. The loops of the muscle are separated by intervals occupied by areolar tissue. This combination of muscular loops and areolar tissue forms the *cremasteric* or *middle spermatic fascia*. The cremaster muscle lies in series with the lower border of the internal oblique, and is peculiar to the male. It is occasionally represented in the female by a few fibres which descend on the round ligament of the uterus in the inguinal canal.

Nerve-supply.—The genital branch of the genito-crural nerve from the lumbar plexus, more particularly from the first, and the ventral division of the second, lumbar nerves.

Action.—To support and raise the testis towards the external abdominal ring. The fibres composing the muscle are of the *striated* variety, but the action is involuntary, and of a reflex character.

Cremasteric Reflex.—The *afferent* nerve involved in the cremasteric reflex is either the **inguinal,** which is distributed to the side of the scrotum and inner side of the thigh, or the **crural branch** of the **genito-crural,** which is distributed to the integument over Scarpa's triangle. The *efferent* nerve is the **genital branch** of the **genito-crural.**

Transversalis Abdominis—*Origin.*—(1) The deep aspect of Poupart's ligament over its outer third; (2) the inner lip of the iliac crest over its anterior two-thirds; (3) the lumbar aponeurosis, which, by its *posterior* lamina, is connected with the spinous processes of the lumbar and sacral vertebræ, and the posterior fourth of the outer lip of the iliac crest, by its *middle* lamina with the tips of the lumbar transverse processes, and, by its *anterior* lamina, with the fronts of the lumbar transverse processes near their tips; and (4) the inner surfaces of the cartilages of the lower six ribs by six slips which interdigitate with slips of the diaphragm.

Insertion.—(1) The linea alba; (2) the front of the pubic crest; and (3) the pectineal portion of the ilio-pectineal line for 1 inch.

Nerve-supply.—This is similar to that of the internal oblique.

Action.—To diminish the capacity of the abdominal cavity, and so compress the viscera. To a limited extent the two muscles aid the external and internal oblique muscles in elevating the pelvis, flexing the thorax, and depressing the ribs.

The most of the fibres pass transversely forwards, and terminate in the anterior aponeurosis. The Poupart fibres, however, pass

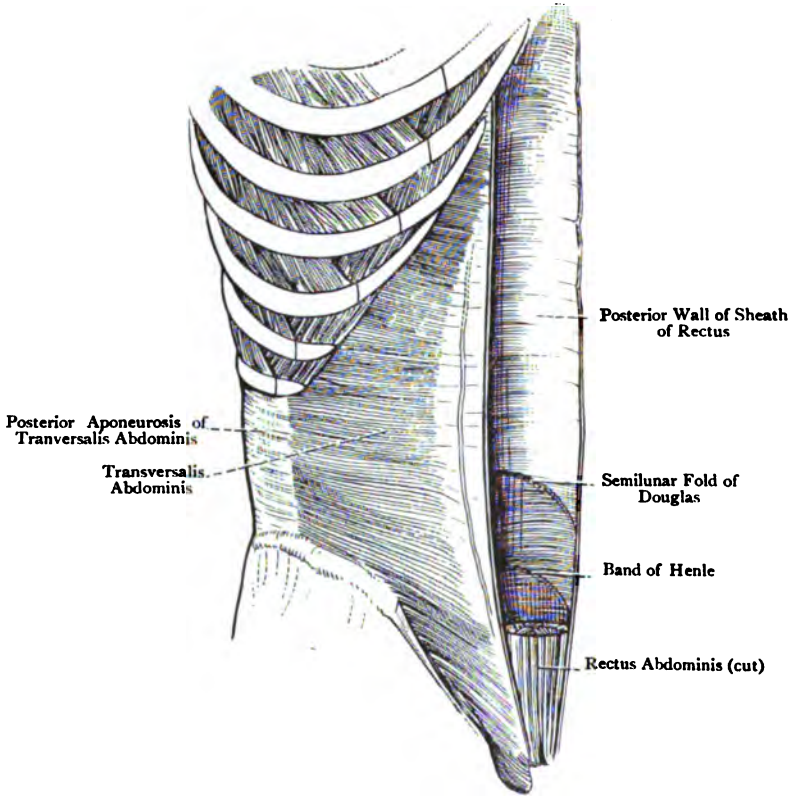


FIG. 277.—THE TRANSVERSALIS ABDOMINIS MUSCLE.

downwards and inwards, and join the corresponding fibres of the internal oblique to form the conjoined tendon. The *anterior aponeurosis* is narrow above, but broad below. Over about the upper three-fourths of the rectus abdominis it passes behind the muscle, but over about the lower fourth it passes in front of it. The transversalis abdominis is continuous superiorly with the triangularis sterni muscle, and its lower border is free where it arches over the spermatic cord, or the round ligament of the uterus.

For the *posterior aponeurosis* of the muscle, see p. 718.

Conjoined Tendon.—This is the tendon which gives a common insertion to the Poupart fibres of the internal oblique and transversalis abdominis muscles. It is *inserted* into (1) the front of the pubic crest, and (2) the pectineal portion of the ilio-pectineal line for 1 inch. The tendon is formed principally by the transversalis abdominis, which extends for 1 inch along the ilio-pectineal line, whilst the internal oblique only extends along that line for ½ inch.

Relations—*Superficial.*—The structures in front of the conjoined tendon, from the middle line outwards, are as follows: the lower part of the internal pillar of the external abdominal ring; the triangular fascia; the insertion of the cremaster; Gimbernat's ligament; the inner part of Poupart's ligament; and the spermatic cord. *Deep.*—The fascia transversalis.

The conjoined tendon varies greatly in development, and in many cases is hardly distinguishable. As a rule, it covers the inner two-thirds of the floor of Hesselbach's triangle, where it lies behind the inner two-thirds of the inguinal canal and has the spermatic cord, or the round ligament of the uterus, as a superficial relation. It also lies directly behind the external abdominal ring, and so strengthens what would otherwise be a weak part of the abdominal wall. In some cases the conjoined tendon is divisible into two parts, the outer being known as the *ligament of Hesselbach*, and the inner as the *ligament of Henle*.

Reflected Tendon of Cooper. — In normal circumstances the conjoined tendon is limited to the first inch of the pectineal portion of the ilio-pectineal line. Sometimes, however, the anterior aponeurosis of the transversalis abdominis is prolonged outwards beyond the normal limit of the conjoined tendon, in the form of a thin semilunar expansion which extends as far as the inner and lower parts of the internal abdominal ring, and is attached inferiorly to the deep crural arch. This semilunar expansion of the conjoined tendon is known as the **reflected tendon of Cooper.** Its concavity is directed outwards, and, when present, it covers the outer third of the floor of Hesselbach's triangle, where it lies behind the spermatic cord, and is closely connected with the subjacent fascia transversalis, to which it imparts strength.

An inspection of the external oblique, internal oblique, and transversalis abdominis muscles shows that they cross each other at different angles, the external oblique passing downwards and forwards, the internal oblique upwards and forwards (these two muscles thus crossing like the limbs of the letter X), and the transversalis horizontally forwards. They thus form an intricate lattice-work which renders the abdominal wall very strong, and is a powerful safeguard against hernial protrusions.

Rectus Abdominis—*Origin.*—This muscle arises by two heads, both of which are tendinous. The **external head**, broad and flat, arises from the pubic crest, and the **internal head**, narrow and somewhat round, from the fibrous structures in front of the symphysis pubis, where it is closely connected with its fellow of the opposite side. The two heads join about 1 inch above the symphysis pubis.

Insertion.—By means of three flat slips, which are at first fleshy and subsequently tendinous, into the anterior surfaces of the fifth, sixth, and seventh costal cartilages. The most internal slip is

sometimes partially inserted into the side of the ensiform process of the sternum.

Nerve-supply.—The lower five intercostal nerves and the subcostal nerve.

Action.—The action is similar to that of the two oblique and transversalis muscles, with the exception that it does not produce lateral rotation of the thorax.

The muscle is long, flat, and strap-like, its fibres being directed vertically upwards by the side of the linea alba. It is narrow below and broad above, its greatest breadth being about 3 inches. Below the umibilcus the two muscles are very near each other, the interval between them being not more than about $\frac{1}{8}$ inch. Above the umbilicus, however, the muscles are separated by an interval of about $\frac{1}{4}$ inch. Each muscle is marked by *tendinous intersections* or *inscriptions*, which cross it in a somewhat irregular manner at certain intervals. They are usually three in number, and are situated as follows : one at the level of the umbilicus, a second opposite the tip of the ensiform process, and a third about midway between these two. Sometimes there is a fourth inscription, which crosses the muscle a little below the umbilicus, but this one is faint, and does not usually extend the whole width. These inscriptions, which do not usually penetrate to the posterior surface, map out the upper part of the muscle into two quadrangular areas, and are firmly bound to the anterior wall of its sheath. Above the level of the umbilicus, therefore, the interior of the sheath, anterior to the muscle, is divided into two distinct compartments.

The tendinous inscriptions are the remains of the septa which separated the primitive myotomes or muscle-segments, and by some they are regarded as indicating the abdominal ribs of certain animals, such as the crocodile.

Pyramidalis Abdominis—*Origin.*—The front of the pubic crest.

Insertion.—The linea alba for 2 inches or more above the symphysis pubis.

Nerve-supply.—The subcostal nerve.

Action.—To render tense the linea alba.

The muscle is sometimes present only on one side ; sometimes it is absent on both sides ; and sometimes it is double on one or both sides. In man it is a small muscle, and vestigial like the plantaris ; but it attains a large size in marsupials, and especially in ornithorhynchus.

Sheath of Rectus Abdominis.—Over about the *upper three-fourths* of the muscle the **anterior wall** is formed by the anterior lamina of the internal oblique aponeurosis and the external oblique aponeurosis, the two being closely connected ; and the **posterior wall** is formed by the posterior lamina of the internal oblique aponeurosis and the anterior aponeurosis of the transversalis abdominis, these two being likewise closely connected. Over about the *lower fourth* the **anterior wall** is formed by the external oblique aponeurosis, the undivided internal oblique aponeurosis, and the

anterior aponeurosis of the transversalis abdominis, in this order from before backwards, all three being closely connected. Over this extent the sheath is deficient posteriorly, and the muscle rests upon the fascia transversalis, with an exception to be presently stated. The lower border of the posterior wall presents a free curved margin, with the concavity downwards, called the **semilunar fold of Douglas**, over which the deep epigastric artery passes. This fold is usually situated about the junction of the upper fourth and lower three-fourths of the infra-umbilical portion of the linea alba. Sometimes the anterior aponeurosis of the transversalis abdominis, though passing in front of the lower fourth of the rectus, sends scattered fibres behind it, which would thus intervene between the muscle and the fascia transversalis for a variable distance below the fold of Douglas. In such cases the posterior wall of the sheath presents another curved semilunar fold, situated from 1 to 2 inches below the semilunar fold of Douglas, and known as the **band of**

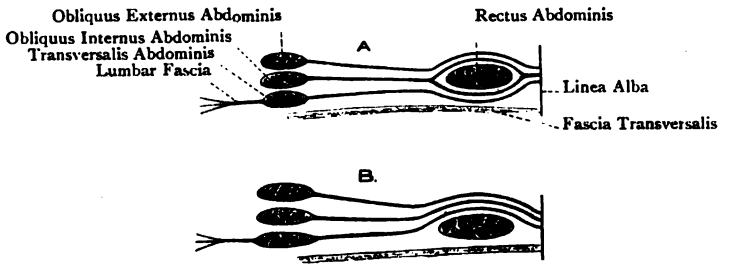


FIG. 278.—DIAGRAM SHOWING THE SHEATH OF THE RECTUS ABDOMINIS.
A, Over the upper three-fourths; B, over the lower fourth.

Henle, over which the deep epigastric artery passes. The **contents** of the sheath are as follows: the rectus abdominis, pyramidalis abdominis, deep epigastric vessels, superior epigastric vessels, and terminal parts of the lower five intercostal, and subcostal, nerves.

Relation of Structures at the Pubic Crest.—The relation of structures from before backwards is as follows:

1. The triangular fascia.
2. The conjoined tendon.
3. The pyramidalis.
4. The outer head of the rectus abdominis.
5. The fascia transversalis.

A few fibres of the cremaster are inserted into the pubic crest close to the pubic spine.

Relation of Structures at the Pectineal Portion of the Ilio-pectineal Line.—The relation of structures from before backwards is as follows:

1. The pubic lamina of the fascia lata, incorporated with which is the pubic ligament of Cooper.
2. The pectineus.
3. Gimbernat's ligament.
4. The conjoined tendon.
5. The fascia transversalis and the deep crural arch.

Deep Nerves of the Abdominal Wall.—The **lower five intercostal nerves,** after leaving the intercostal spaces, lie between the internal oblique and transversalis abdominis, and pass downwards and forwards to the outer border of the rectus. Here they pierce, in succession, the posterior wall of the sheath, the rectus, and the anterior wall of the sheath, after which they terminate in the anterior cutaneous nerves. In their course they supply the two oblique, the transversalis, and the rectus muscles. Each nerve gives off a lateral cutaneous branch in the mid-axillary line. These lateral cutaneous branches, having pierced the internal oblique, appear between the slips of the external oblique and divide into anterior and posterior branches.

The **subcostal nerve** is the anterior primary division of the twelfth thoracic nerve. It is in series with the eleventh intercostal, but is not ranked as an intercostal nerve, inasmuch as it lies along the lower border of the twelfth rib. It is commonly spoken of as the *last dorsal nerve.* Its abdominal relations, course, and distribution are similar to the preceding nerves, with an additional distribution to the pyramidalis abdominis. Its *lateral cutaneous* or *iliac branch*, which is undivided, having pierced the internal and external oblique muscles, descends over the anterior part of the iliac crest, 1 inch behind the anterior superior iliac spine, and is distributed to the integument of the anterior part of the gluteal region as low as the great trochanter of the femur.

The **ilio-hypogastric nerve**, having pierced the posterior part of the transversalis abdominis a little above the iliac crest, furnishes its *iliac branch* (lateral cutaneous), which perforates the internal and external oblique, and, having crossed the iliac crest at the junction of its middle and anterior thirds, is distributed to the integument of the adjacent part of the gluteal region. The nerve then continues its course forwards between the internal oblique and transversalis, supplying branches to these muscles and communicating with the inguinal nerve. About 1 inch in front of the anterior superior iliac spine it pierces the internal oblique, and runs forwards between the Poupart fibres of that muscle and the external oblique aponeurosis. Finally, it pierces that aponeurosis about 1 inch above the external abdominal ring, and is distributed to the integument of the suprapubic region, where it is in series with the anterior cutaneous nerves.

The **inguinal nerve** (ilio-inguinal), as it passes forwards, lies internal to the inner lip of the iliac crest, beneath the transversalis and upon the iliac fascia and iliacus muscle. Near the anterior part of the iliac crest it pierces the transversalis, and here communicates with the hypogastric branch of the ilio-hypogastric. It subsequently perforates the Poupart fibres of the internal oblique, after which it descends through the lower two-thirds of the inguinal canal, and emerges through the external abdominal ring where it lies external to the spermatic cord. Finally, it is distributed to the integument of the inner side of the thigh in its upper third,

and to the integument of the scrotum, or labium majus, according to the sex. The nerve in its course supplies branches to the internal oblique and transversalis muscles.

Deep Arteries of the Abdominal Wall.—The **deep epigastric artery** arises from the inner side of the external iliac, about ½ inch above Poupart's ligament. For a very short distance at first it passes inwards between Poupart's ligament and the lower border of the internal abdominal ring. It then changes its course, and passes upwards and inwards, lying close to the inner side of the internal abdominal ring, only the external vena comes intervening. On arriving at the outer border of the rectus abdominis, at a point about midway between the upper border of the symphysis pubis and the umbilicus, the artery passes beneath the muscle and enters the sheath over the semi-lunar fold of Douglas. It then changes its course, and ascends vertically between the muscle and the posterior wall of the sheath, as high as the umbilicus. Thereafter it enters the muscle, and, about 2 inches above the umbilicus, it ends in its terminal branches, which anastomose with branches of the superior epigastric artery. The deep epigastric lies at first in the subperitoneal areolar tissue, having the parietal peritoneum on its deep surface, and the fascia transversalis superficial to it. Shortly after passing the internal abdominal ring the vessel pierces the fascia transversalis, and in its course to the outer border of the rectus it forms the outer boundary of Hesselbach's triangle. As the vessel turns from the lower border to the inner side of the internal abdominal ring it has the spermatic cord in front of it, and the vas deferens here hooks round its outer side. The course of the vessel in its first or oblique part is indicated by a line drawn from the inner border of the internal abdominal ring to the outer border of the rectus abdominis at a point about midway between the umbilicus and the upper border of the symphysis pubis. The course of the second or vertical part of the vessel is represented by a vertical line corresponding with the centre of the rectus, and distant from the linea alba about 1½ inches.

Branches.—These are as follows: cremasteric, pubic, muscular, cutaneous, peritoneal, and terminal or anastomotic.

The *cremasteric artery* enters the spermatic cord and supplies the cremaster muscle and the other coverings of the cord. It anastomoses with the spermatic artery, the superior and inferior external pudic arteries, and the superficial perineal artery. The cremasteric artery is replaced in the female by the *artery of the round ligament of the uterus.*

The *pubic artery* passes inwards behind the inner half of Poupart's ligament to the back of the body of the os pubis, where it anastomoses with the pubic branch of the obturator artery and its fellow of the opposite side.

The *muscular branches* arise chiefly from the outer side of the deep epigastric, and supply the two oblique, transversalis, and

rectus muscles. They anastomose with the lower two intercostal arteries, the subcostal artery, the abdominal branches of the lumbar arteries, and the lateral or intermuscular epigastric (so called 'ascending branch') of the deep circumflex iliac artery.

The *cutaneous branches* perforate the rectus and the anterior wall of its sheath, to be distributed to the integument in which they anastomose with branches of the superficial epigastric.

The *peritoneal branches* pierce the posterior wall of the sheath of the rectus, to be distributed to the adjacent parietal peritoneum.

The *terminal* or *anastomotic branches* enter the rectus above the level of the umbilicus and anastomose with the superior epigastric of the internal mammary.

For an abnormal or aberrant obturator artery, see p. 436.

There are two venæ comites with the deep epigastric artery, one on either side. These ultimately join to form one vessel, which terminates in the external iliac vein.

The **superior epigastric artery** is one of the terminal branches of the internal mammary from the first part of the subclavian. It descends behind the seventh costal cartilage, passing between the sternal and costal portions of the diaphragm, and enters the sheath of the rectus, where it lies at first between the muscle and the posterior wall of its sheath. It then enters the muscle and anastomoses with the deep epigastric. Its branches are as follows: *metasternal*, which crosses in front of the metasternum and anastomoses with its fellow of the opposite side; *phrenic*, to the diaphragm; *muscular* to the muscles of the abdominal wall; *anterior cutaneous* to the integument; *falciform* or *hepatic* (present only on the right side), which passes to the liver in the falciform ligament and anastomoses with the hepatic artery; and *peritoneal*, which pierce the posterior wall of the sheath of the rectus, to be distributed to the adjacent parietal peritoneum. The vessel is accompanied by two venæ comites, which terminate in those of the internal mammary artery.

The **deep circumflex iliac artery** arises from the outer side of the external iliac nearly opposite the origin of the deep epigastric. It passes outwards and upwards behind the outer half of Poupart's ligament, where it is contained in a canal formed at the junction of the fascia transversalis and fascia iliaca. Having arrived at the anterior superior iliac spine, it pierces the fascia transversalis, and courses outwards and backwards along the iliac crest on its inner aspect. At its termination it anastomoses with the lumbar branch of the ilio-lumbar from the internal iliac. Over about the anterior half of the iliac crest the artery lies beneath the transversalis muscle, but about the centre of the crest it pierces that muscle, and subsequently lies between it and the internal oblique.

Branches. — In the first part of its course the vessel gives branches to the ilio-psoas, sartorius, and tensor fasciæ femoris, in which latter muscle it anastomoses with the ascending branch of the external circumflex from the arteria profunda femoris.

As it courses along the iliac crest it furnishes branches to the muscles of the abdominal wall, some of which reach the gluteal region, where they anastomose with the gluteal of the internal iliac and the superficial circumflex iliac of the common femoral. It also gives branches to the iliacus muscle, which anastomose with the iliac branch of the ilio-lumbar from the internal iliac. One of the muscular branches of the artery is very constant and of large size. It springs from the vessel near the anterior superior iliac spine, and, having pierced the fascia transversalis and transversalis muscle, it ascends vertically between that muscle and the internal oblique, where it anastomoses with the abdominal branches of the lumbar arteries. This branch is usually spoken of as *the ascending branch*, but it may be called the *lateral* or *intermuscular epigastric*.

The deep circumflex iliac artery is accompanied by two venæ comites. These ultimately join to form one vessel, which crosses the external iliac artery from without inwards about ½ inch above Poupart's ligament, and terminates in the external iliac vein.

The **lower two intercostal arteries** ultimately leave the tenth and eleventh intercostal spaces and pass towards the rectus muscle, lying in their course between the internal oblique and transversalis. They anastomose with the superior epigastric, deep epigastric, and subcostal arteries.

The **subcostal artery** lies below the last rib, and is in series with the aortic intercostal arteries above and the lumbar arteries below. On the abdominal wall it anastomoses with the last intercostal, the abdominal branch of the first lumbar, and the superior epigastric, arteries.

The **abdominal branches of the lumbar arteries** pass forwards towards the rectus abdominis. They anastomose with the deep epigastric, subcostal, and lateral or intermuscular epigastric of the deep circumflex iliac.

The veins corresponding to the lower two intercostal arteries terminate in the corresponding intercostal veins. The subcostal vein of the right side terminates in the right azygos vein, and that of the left side in the lower left azygos vein. The veins accompanying the abdominal branches of the lumbar arteries terminate in the lumbar veins, which are tributaries of the inferior vena cava.

Deep Lymphatics.—The deep lymphatics of the lower part of the *anterior* abdominal wall accompany the deep epigastric and deep circumflex iliac vessels, and terminate in the external iliac glands; those of the upper part accompany the superior epigastric artery, and terminate in the sternal glands.

The deep lymphatics of the lower part of the *lateral* abdominal wall accompany the abdominal branches of the lumbar arteries and the ilio-lumbar artery, and terminate in the lateral group of lumbar glands; those of the upper part accompany the adjacent anterior intercostal and musculo-phrenic arteries, and terminate in the sternal glands.

For the superficial lymphatics of the antero-lateral abdominal wall, see p. 607.

Fascia Transversalis.—The fascia transversalis is situated underneath the transversalis abdominis muscle. It is of greatest strength over the lower part of the abdominal wall, particularly between the lower free border of the transversalis and Poupart's ligament. When traced upwards to the costal margin it becomes very thin, and is there continuous with the fascia which covers the abdominal surface of the diaphragm. Along the linea alba it is continuous with the fascia of the opposite side. In the lumbar region it is continuous with the anterior wall of the sheath of the quadratus lumborum. In the region of the iliac crest it is attached to the anterior two-thirds of the crest immediately internal to its inner lip, where it meets and becomes continuous with the fascia iliaca, both of these fasciæ being here interposed between the transversalis and iliacus muscles. The most important disposition of the fascia is along the line of the groin, where its attachments are as follows: along the outer half of Poupart's ligament it is firmly attached to that ligament on its deep aspect, and over that extent it meets and is continuous with the fascia iliaca, the two fasciæ here forming a canal, which contains the deep circumflex iliac vessels. In the situation of the external iliac vessels, and as far inwards as the base of Gimbernat's ligament, it is only loosely attached to Poupart's ligament, and is here prolonged downwards beneath the ligament to the thigh, where it lies in front of the common femoral vessels, and forms the anterior wall of the crural sheath. As the fascia is prolonged beneath Poupart's ligament it is strengthened by superadded fibres, which are known as the *deep crural arch*. In the region of Gimbernat's ligament the fascia is attached in succession to the pectineal portion of the ilio-pectineal line behind the conjoined tendon, and to the pubic crest. Behind the symphysis pubis the fascia descends into the pelvis, and becomes continuous with the pubo-prostatic, or anterior true, ligaments of the bladder. The strongest part of the fascia transversalis, as before stated, is between the lower free border of the transversalis muscle and Poupart's ligament, this part of the abdominal wall being uncovered by muscular structures. It is in this situation where the fascia is pierced by the spermatic cord in the male and the round ligament of the uterus in the female.

Internal Abdominal Ring.—This ring is situated in the fascia transversalis at a point midway between the symphysis pubis and the anterior superior iliac spine, and ½ inch above Poupart's ligament. It serves for the passage of the spermatic cord in the male and the round ligament of the uterus in the female. As viewed from before no opening is visible in the undissected state, because the fascia transversalis is prolonged from the margins of the aperture round the spermatic cord as the infundibuliform or internal spermatic fascia. When fully dissected the ring is oval, with the long axis lying vertically, in which direction it measures ¾ inch,

the transverse measurement being ½ inch. The deep epigastric artery lies at first *below*, and then on the *inner* side of, the ring, the vessel being here beneath the fascia transversalis. The reflected tendon of Cooper may be upon the inner side of, and below, the ring. On the outer side of the ring are the Poupart fibres of the internal oblique, and above is the lower free border of the transversalis. The fascia at the outer and lower parts of the ring is stronger than elsewhere.

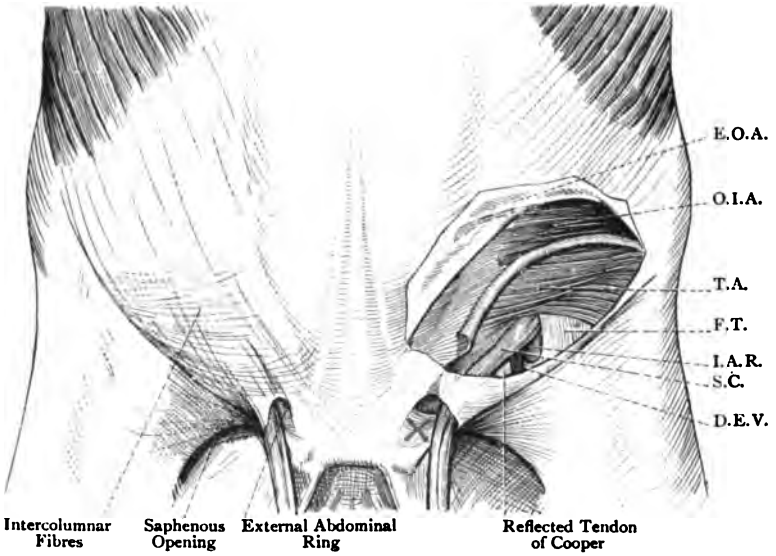


FIG. 279.—SUPERFICIAL AND DEEP DISSECTION OF THE LOWER PART OF THE ANTERIOR ABDOMINAL WALL (AFTER COOPER).

E.O.A. External Oblique Aponeurosis
O.I.A. Obliquus Internus Abdominis
T.A. Transversalis Abdominis
F.T. Fascia Transversalis
I.A.R. Internal Abdominal Ring
S.C. Spermatic Cord
D.E.V. Deep Epigastric Vessels
X. Triangular Fascia

Inguinal Canal.—The inguinal canal is the oblique passage in the lower part of the anterior abdominal wall, which transmits the spermatic cord, or round ligament of the uterus, according to the sex, and also the inguinal nerve in its lower two-thirds. It is situated immediately above the inner half of Poupart's ligament, its direction being downwards, forwards, and inwards, and it is 1½ inches in length. The inlet to the canal is the internal abdominal ring, the outlet being the external abdominal ring. Its component parts are a floor, a roof, an anterior wall, and a posterior wall. The **floor** in its upper two-thirds is formed by the meeting between the fascia transversalis and Poupart's ligament. This portion of it presents a groove, which lodges the spermatic cord. In the lower third the floor is formed by the

abdominal surface of Gimbernat's ligament along its line of junction with Poupart's ligament. The **roof** is formed by the apposition of the external and internal oblique muscles, and also by the lower borders of the internal oblique and transversalis. The **anterior wall** is formed by the following structures from before backwards: (1) the skin; (2) fascia of Camper; (3) fascia of Scarpa; (4) external oblique aponeurosis (all of these four structures extending over the whole length of the anterior wall); and (5) the Poupart portion of the internal oblique over the outer third. The **posterior wall** is formed by the following structures, in order from behind forwards: (1) the parietal peritoneum; (2) subperitoneal fat; (3) fascia

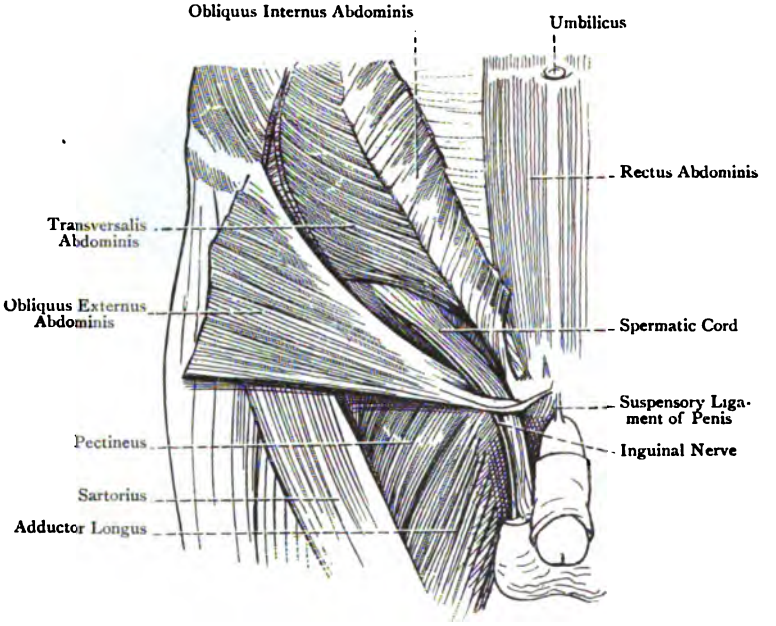


FIG. 280.—DISSECTION OF THE INGUINAL REGION.

transversalis; (4) conjoined tendon over the inner two-thirds, and it may be, the reflected tendon of Cooper over the outer third; and (5) the outer portion of the triangular fascia (provided that fascia is well developed), which lies over the extreme inner part of this wall.

In early life the inguinal canal is very short. Indeed, at one period of life it is non-existent, inasmuch as the internal abdominal ring in very early life lies directly behind the external ring. As the pelvis, however, increases in breadth, the internal ring is gradually shifted outwards, and so the inguinal canal becomes formed.

The inguinal canal in the female differs from that in the male in

being of smaller size, and in containing the round ligament of the uterus.

Triangle of Hesselbach.—This triangle is situated at the lower part of the anterior abdominal wall above the inner half of Poupart's ligament.

Boundaries—*Internal.*—The outer border of the rectus abdominis over about its lower 2 inches. *External.*—The deep epigastric vessels. *Inferior* (base).—The inner half of Poupart's ligament. The *apex* corresponds with the point where the deep epigastric vessels pass beneath the outer border of the rectus. The *floor* is covered over its whole extent by the fascia transversalis, superficial to which, over the inner two-thirds, is the conjoined tendon, and over the outer third, sometimes the reflected tendon of Cooper. The floor is, therefore, conveniently divided into an inner two-thirds, where the conjoined tendon lies, and an outer third, where the reflected tendon of Cooper may be situated. The triangle is covered superficially by the skin, the fasciæ of Camper and of Scarpa, and the external oblique aponeurosis.

Spermatic Cord.—The spermatic cord extends from the internal abdominal ring to the upper part of the posterior border of the testis. For the first 1½ inches of its course it lies in the inguinal canal, and is directed downwards, forwards, and inwards. After passing through the external abdominal ring it enters the scrotum, in which it descends almost vertically. The relations of the cord in the inguinal canal will be understood on referring to the description of that canal. In the lower two-thirds of the canal it is accompanied by the inguinal nerve.

The spermatic cord is composed of the following structures: the vas deferens or excretory duct of the testis; three arteries, namely, the spermatic artery, the artery of the vas deferens, and the cremasteric artery; the spermatic or pampiniform plexus of veins; the lymphatics of the testis and epididymis; the spermatic plexus of sympathetic nerves; and the genital branch of the genito-crural nerve. These structures are connected by areolar tissue, and the cord receives certain coverings to be presently described.

The **vas deferens** is the excretory duct of the testis. It commences at the lower end or globus minor of the epididymis, and terminates at the base of the prostate gland by joining the duct of the vesicula seminalis to form the common ejaculatory duct. This latter duct, having passed through the prostate gland for about 1 inch, opens upon (sometimes within) the margin of the opening of the sinus pocularis or prostatic vesicle on the floor of the prostatic portion of the urethra. The vas deferens at its commencement is slightly tortuous, but it soon becomes straight. It lies at first on the inner side of the epididymis, and along the posterior border of the testis. After entering the cord it is placed *behind* all the other elements, where it can be readily felt. It maintains this position until it arrives at the internal abdominal ring, where it lies on the *inner* side of the other elements of the cord.

After passing through the internal abdominal ring it hooks round the outer side of the deep epigastric artery, and, having crossed the external iliac vessels from without inwards, it dips down on the inner side of the external iliac vein, and so enters the pelvis under cover of the peritoneum, where it will be afterwards described. The vas deferens in its natural state measures about 1 foot in length, but when straightened it attains a length of from 1½ to 2 feet.

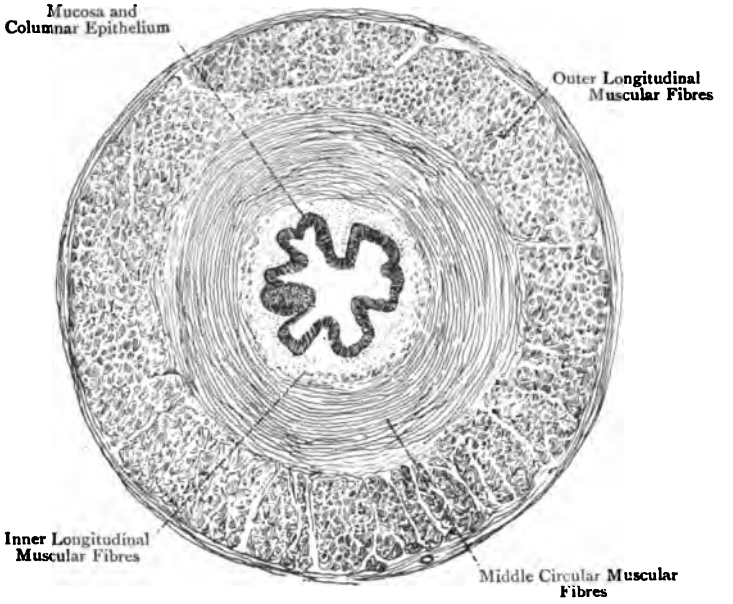


FIG. 281.—TRANSVERSE SECTION OF THE VAS DEFERENS, SHOWING ITS MINUTE STRUCTURE.

Structure of the Vas Deferens.—The vas deferens has a very thick wall, and feels like a piece of whip cord. Its outer coat consists of fibrous tissue. Within this there is a thick muscular coat composed of plain muscular tissue, which is arranged in three layers—an outer longitudinal, a middle circular (both of which are thick), and an inner thin longitudinal layer. Within the muscular coat is the mucosa, which is covered by non-ciliated columnar epithelium. The lumen of the tube has a diameter of about $\frac{1}{30}$ inch.

The **artery of the vas deferens,** or **deferential artery,** is usually a branch of the superior vesical of the internal iliac, though it may arise from the inferior vesical, and it divides into a descending and an ascending branch. The *descending branch* passes downwards to supply the lower part of the vas deferens and the vesicula seminalis. The *ascending branch* accompanies the vas deferens through the inguinal canal to the testis, supplying the vas deferens, and giving a few twigs to the globus minor of the epididymis, in which latter situation it anastomoses with the epididymal branch

of the spermatic artery. The deferential artery is sometimes of large size, and then it takes the place of the spermatic artery when that vessel is absent.

The **deferential vein** opens into the vesical plexus of veins, and thence into the internal iliac vein.

The **spermatic artery** arises from the abdominal aorta about 1 inch below the renal artery. On approaching the upper part of the testis it divides into *testicular* and *epididymal branches*, the former supplying the testis and the latter the epididymis. As

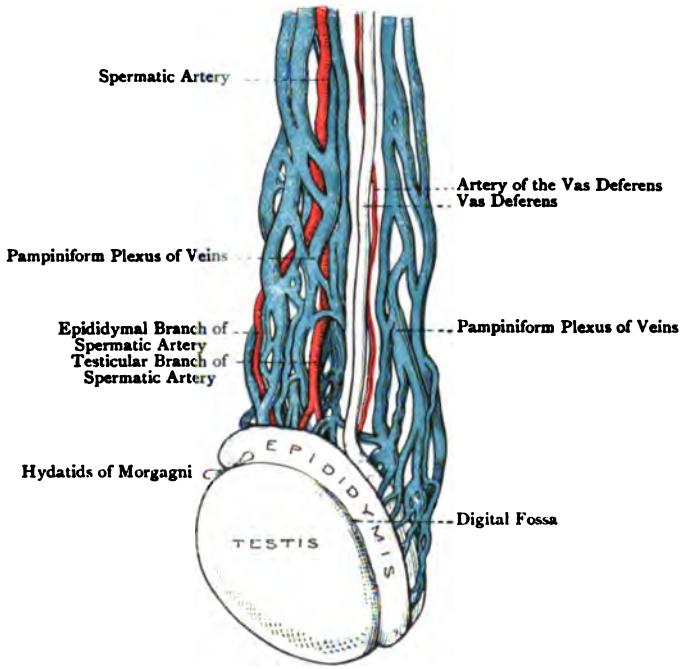


FIG. 282.—DISSECTION OF THE SPERMATIC CORD, SHOWING THE BLOOD-VESSELS AND DUCT OF THE TESTIS (AFTER SAPPEY).

the artery descends in the spermatic cord it supplies branches to its coverings which anastomose with the cremasteric artery, and its epididymal branches anastomose with the deferential artery.

For the **cremasteric artery,** see p. 623.

The **spermatic veins** issue from the testis along its posterior border. In the cord they form a copious plexus, called the **pampiniform plexus.** At the internal abdominal ring two veins emerge from this plexus, which range themselves on either side of the spermatic artery. These, as they ascend, soon join to form one vessel, that of the *right* side opening into the inferior vena cava, and that of the *left* side into the left renal vein. The veins of

the spermatic plexus have valves, but they are not competent. There is, however, a competent valve as a rule at the termination of each spermatic vein.

The lymphatics of the testis and spermatic cord, the spermatic plexus of sympathetic nerves, and the genital branch of the genito-crural nerve will be afterwards described.

Coverings of the Spermatic Cord.—The coverings, enumerated from within outwards, are as follows :

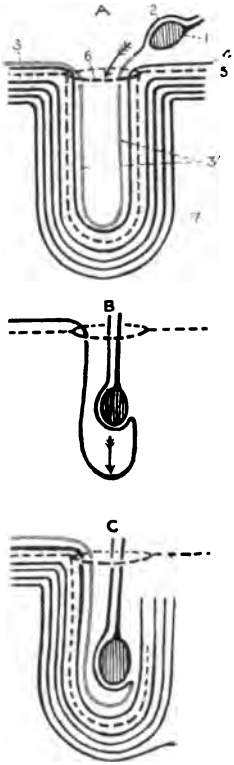
1. The subperitoneal areolar tissue, which is continuous with that of the abdominal wall through the internal abdominal ring. It contains a certain amount of muscular tissue, which is known as the *middle cremaster*.
2. The fascia transversalis, prolonged from the margins of the internal abdominal ring, and known as the *internal spermatic fascia*. This covering near the ring is funnel-shaped, and is thence called the *infundibuliform fascia*, but lower down it becomes incorporated with the subperitoneal areolar tissue, and forms the *fascia propria* of Cooper.
3. The cremasteric fascia, or *middle spermatic fascia*.
4. The intercolumnar fascia, or *external spermatic fascia*.
5. The tunica dartos.
6. The skin.

Within the innermost of these coverings there are a few scattered muscular fibres, which constitute the *internal cremaster of Henle*, and which are regarded as representing the inverted lateral bands of the gubernaculum testis.

It is to be noted that the *middle cremaster* is the muscular tissue contained in the subperitoneal areolar tissue on the surface of the cord, whilst the *external cremaster* is the more distinct muscular structure which is derived from the lower border of the internal oblique. The fibres of the external cremaster are of the striated variety, but those of the middle and internal are of the plain variety.

Descent of the Testis.—The testis is originally situated in the abdominal cavity upon the psoas magnus muscle, below and behind the kidney. It is almost completely invested by the peritoneum, which forms a fold behind it, called the **mesorchium.** This is to be regarded as a peritoneal ligament attaching the testis to the posterior abdominal wall, and so holding it in position. At this period there is present a band of plain muscular fibres, called the **gubernaculum testis.** The gubernaculum is attached superiorly to the lower part of the testis, and also to the peritoneum lining the adjacent portion of the posterior abdominal wall. Inferiorly, in the inguinal region, it is disposed in three divisions—external, internal, and middle. The external division is attached to the abdominal wall close to the internal abdominal ring, the internal to the pubic crest, and the middle to the integument of the groin which subsequently forms the scrotum. The descent of the testis commences about the third or fourth month of intra-uterine life, and, as it descends, it carries its *primitive peritoneum* along with it. It arrives at the internal abdominal ring about the sixth month, where it remains stationary until about the seventh month. At this latter period it commences its descent through the inguinal canal, and, by the eighth month it has usually reached the scrotum, the left testis arriving there a little earlier than the right.

Preparatory to the descent of the testis through the inguinal canal a diverticulum of the parietal peritoneum, called the **processus vaginalis,** passes through the inguinal canal into the scrotum. This process carries before it coverings from the fascia transversalis, from the lower border of the internal oblique muscle (cremaster muscle), and from the pillars of the external abdominal ring (intercolumnar or external spermatic fascia). The testis, covered by its primitive peritoneum, enters the pouch formed by the pro-



283.—DIAGRAM SHOWING THE DESCENT OF THE TESTIS.

A, First Stage; B, Second Stage; C, Final Stage.

1. Testis (in Abdomen)
2. Primitive Peritoneum (Tunica Adnata)
3. Parietal Peritoneum
3'. Processus Vaginalis
4. Subperitoneal Areolar Tissue
5. Fascia Transversalis
6. Internal Abdominal Ring
7. Integument

cessus vaginalis, and so descends through the inguinal canal into the scrotum, accurately following the lead of the middle division of the gubernaculum testis. During the descent of the testis from its original position to the internal abdominal ring all three divisions of the gubernaculum testis are being shortened. When the organ has arrived at the internal ring the external and internal divisions are practically horizontal, and, during its further descent into the scrotum, these two divisions are elongated in an

inverse or downward direction, their fasciculi becoming very scattered, and representing the so-called internal cremaster muscle. When the testis has reached the scrotum the middle gubernacular division has necessarily become extremely short, and it is ultimately represented by a little fibrous tissue which attaches the lower part of the testis to the bottom of the scrotal chamber.

Certain changes take place in the processus vaginalis after the testis has reached the scrotum. In the first place, the upper opening of the processus vaginalis becomes closed just before birth, and then the interior of the process represents an elongated shut sac. In the second place, a few days after birth, the process becomes constricted and closed just above the testis. The part above this latter closure, and as high as the internal abdominal ring, becomes impervious, and usually disappears in the first month after birth; but the part below it remains persistent, and forms the *parietal portion* of the tunica vaginalis. The *visceral portion* of the tunica vaginalis is formed by the primitive peritoneum which originally covered the testis whilst in the abdomen, and which the organ carries along with it in its descent; hence the visceral portion is sometimes called the **tunica adnata** ('born to'). In normal cases all that is left in the adult of the original processus vaginalis is (1) the lower part, which forms the parietal portion of the tunica vaginalis (tunica

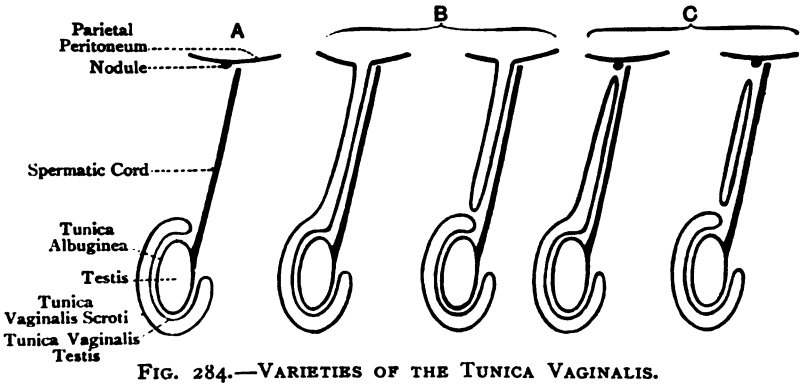


FIG. 284.—VARIETIES OF THE TUNICA VAGINALIS.

A, Normal Type; B, Congenital Type; C, Infantile Type.

vaginalis scroti), and (2) a small nodule upon the parietal peritoneum immediately behind the internal abdominal ring. Instead of a mere nodule, however, a delicate fibrous thread, known as the **ligamentum vaginale,** may extend from this part of the peritoneum downwards upon the front of the spermatic cord as far as the external abdominal ring, and in some cases as low as the tunica vaginalis.

Two views are held as to the descent of the testis. One view is that the descent of the organ is brought about by the contraction of the gubernacular fibres, and according to this view the external and internal gubernacular divisions would draw the testis down to the internal and external abdominal rings respectively, whilst the middle gubernacular division would steer or guide it into the scrotum. The other view is that the descent is brought about by developmental changes which are gradually taking place at this period in the surrounding parts.

Abnormal Conditions of the Processus Vaginalis—Congenital Type.—(1) The processus vaginalis may remain permanently open throughout, under which circumstances the cavity of the tunica vaginalis is in direct communication with the general peritoneal cavity. (2) The processus vaginalis may be closed just above the tunica vaginalis, but it may remain as a permanently open tube above this point.

Infantile or Funicular Type.—(1) The processus vaginalis may be closed only at its upper end near the internal abdominal ring. In these cases the tunica vaginalis, instead of being limited to the region of the testis, is prolonged upwards as an elongated tube in front of the spermatic cord into the inguinal canal. (2) The processus vaginalis may be closed above, near the internal abdominal ring, and also below, just above the tunica vaginalis, the portion of it intervening between these two points remaining as an elongated tube, closed at either end, and lying in front of the spermatic cord.

The funicular portion of the processus vaginalis is sometimes closed at intervals along the course of the spermatic cord, and, when serous fluid accumulates in the intervening patent portions, the condition is known as encysted hydrocele of the cord.

For the structure and development of the testis, see pp. 642, 644.

Subperitoneal Fat or **Areolar Tissue.**—This is situated between the fascia transversalis and the parietal peritoneum. Its condition is subject to much variety, being fairly well marked in some bodies, and in others hardly perceptible. Internal to the external iliac vein at Poupart's ligament it forms the *septum crurale*, which closes the upper end of the crural canal, and at the internal abdominal ring it is carried downwards round the spermatic cord underneath the infundibuliform fascia.

Parietal Peritoneum.—This is the innermost covering of the abdominal wall, and it is connected with the fascia transversalis by the subperitoneal areolar tissue. Behind the internal abdominal ring it forms a slight projection, which in some cases enters the ring, the corresponding depression on its abdominal aspect at this point being known as the **digital fossa.** The projecting part of the parietal peritoneum corresponds with the upper end of the original processus vaginalis, and presents a slight nodule, or it may be a slender thread-like process. It is here in the female where a diverticular process may extend for a short distance into the inguinal canal in front of the round ligament of the uterus, forming the canal of Nuck.

Peritoneal Plicæ and Inguinal Fossæ.—The peritoneum lining the posterior surface of the anterior abdominal wall below the umbilicus presents plicæ or folds and fossæ or pouches.

The **plicæ** are five in number, one being situated in the middle line, and two on either side. The median plica extends from the apex of the bladder to the umbilicus, and contains the urachus. It is called the **plica urachi.** Of the two lateral plicæ the more internal one contains the obliterated hypogastric artery, and is called the **plica hypogastrica.** It is oblique in direction, and meets the plica urachi and its fellow of the opposite side at the umbilicus. It corresponds to the junction of the inner two-thirds and outer third of Hesselbach's triangle. The external of the two lateral plicæ is produced by the deep epigastric artery, and is called the **plica epigastrica.**

The **inguinal fossæ** are six in number, three right and three left, and are called internal, middle, and external. The **internal inguinal fossa** is situated between the plica urachi and plica hypogastrica, and lies behind the inner two-thirds of Hesselbach's

triangle, the conjoined tendon, and the external abdominal ring. The **middle inguinal fossa** is situated between the plica hypogastrica and plica epigastrica, and lies behind the outer third

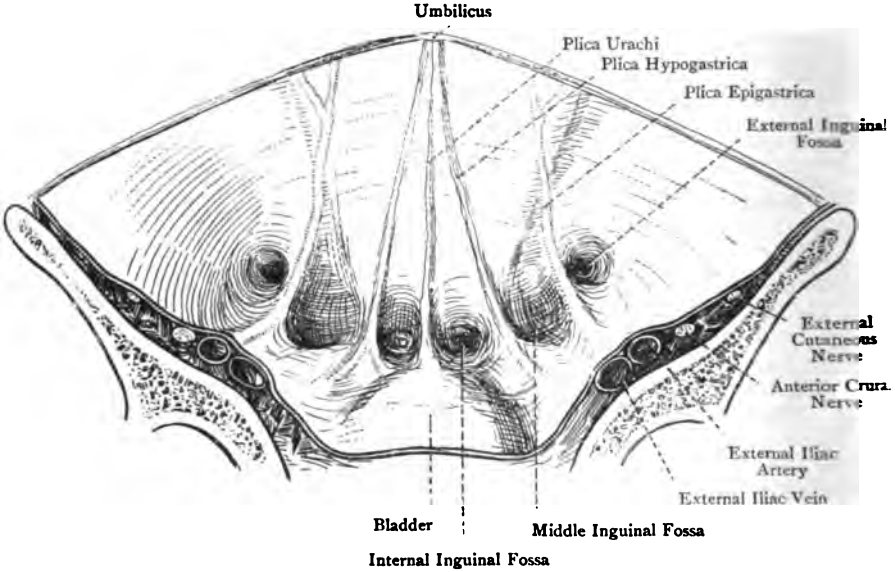


FIG. 285.—THE PLICÆ AND FOSSÆ ON THE POSTERIOR SURFACE OF THE ANTERIOR ABDOMINAL WALL.

of Hesselbach's triangle. The **external inguinal fossa** is situated on the outer side of the plica epigastrica, and its lower and inner part is behind the internal abdominal ring.

INGUINAL HERNIA.

By an inguinal hernia is meant a protrusion of a viscus (usually bowel, or, it may be, great omentum) from the abdominal cavity in the inguinal region. This region is predisposed to such an occurrence from the presence of the two abdominal rings and inguinal canal, and the inguinal fossæ. All forms of inguinal hernia, if complete, ultimately protrude through the external abdominal ring, and thereafter enter the scrotum. Relatively to the deep epigastric artery there are two varieties of inguinal hernia, namely, external and internal, the former leaving the abdominal cavity external to that vessel, and the latter escaping internal to it. Inasmuch, however, as the region inside the deep epigastric artery, namely, Hesselbach's triangle, is divisible into an inner two-thirds and an outer third, there may be two forms of internal hernia. Viewing, therefore, inguinal hernia in its relation to the abdominal wall, there are three varieties, namely, external oblique, internal direct, and internal oblique.

External Oblique Inguinal Hernia.—This variety is called *external* because the hernia, as it leaves the abdominal cavity, is external to the deep epigastric artery, and *oblique*, from its oblique course. The course of the hernia is as follows: it enters the external inguinal fossa, and elongates

before it the peritoneum forming that fossa. It then passes through the internal abdominal ring, and traverses the entire length of the inguinal canal, from which it emerges through the external abdominal ring into the scrotum, thus forming a complete external oblique inguinal hernia. Throughout its entire course the hernia lies in front of the spermatic cord, and its descent is arrested at the upper part of the testis, which can be felt at its lower and back part. The bowel may be arrested at any part of the inguinal canal, the hernia being then called incomplete, and forming what is known as a *bubonocele*. In its descent the bowel elongates and carries before it certain investments from the structures to which it is related, these investments being called the **coverings** of the hernia. The first covering of this form of hernia, as of the other varieties, is derived from the parietal peritoneum, the particular part being that which forms the external inguinal fossa, and this constitutes the **sac.** The other coverings are simply those of the spermatic cord, which are all superadded to the sac.

The **coverings,** enumerated in order from within outwards, are as follows:

1. Parietal peritoneum, which forms the sac.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis, from the margins of the internal abdominal ring, forming the infundibuliform or internal spermatic fascia.
4. Cremasteric or middle spermatic fascia, at the lower border of the internal oblique muscle.
5. Intercolumnar or external spermatic fascia, from the pillars of the external abdominal ring.
6. Tunica dartos.
7. Skin.

A short distance below the internal abdominal ring the subperitoneal fat and infundibuliform fascia become united, and are known as the **fascia propria.**

The **sac** is composed of the following parts: (1) the *mouth*, which is the opening by which its interior communicates with the general peritoneal cavity; (2) the *neck*, which is the constricted part immediately beyond the mouth; and (3) the *body*. The neck of the sac is on a level with the margins of the internal abdominal ring, and the deep epigastric vessels lie immediately on its *inner* side.

The seat of stricture may be (1) at the external abdominal ring; (2) at the lower border of the internal oblique muscle; or (3) at the neck of the sac, the last being the most common situation.

Internal Direct Inguinal Hernia.—This variety is called *internal* because the hernia, as it leaves the abdominal cavity, is internal to the deep epigastric artery, and *direct*, from its straight course through the abdominal parieties. The course of this variety is as follows: the hernia enters the internal inguinal fossa, elongating before it the peritoneum forming that fossa. It then passes through the inner two-thirds of Hesselbach's triangle, and so reaches directly the external abdominal ring without traversing the inguinal canal. Having emerged through the external ring it descends into the scrotum, thus forming a complete internal direct inguinal hernia, which is in front of, and internal to, the spermatic cord. It is to be noted (1) that there is no natural opening in the fascia transversalis over the inner two-thirds of Hesselbach's triangle, as there is external to the deep epigastric artery, and (2) that the conjoined tendon covers the inner two-thirds of Hesselbach's triangle. The coverings of this variety, enumerated in order from within outwards, are as follows:

1. Parietal peritoneum.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis.
4. Conjoined tendon.
5. Intercolumnar or external spermatic fascia.
6. Tunica dartos.
7. Skin.

If the hernia occurs suddenly, rupture of the conjoined tendon may take place, in which cases the bowel would pass through the fissure. The seat of

stricture in an internal direct inguinal hernia may be (1) at the external abdominal ring, (2) at the fissure in the conjoined tendon, if that structure should be ruptured, or (3) at the neck of the sac. The latter situation is the most common, and it is to be noted that the deep epigastric vessels lie on the *outer* side of the neck of the sac.

Internal Oblique Inguinal Hernia.—This variety is called *internal* because the hernia, as it leaves the abdominal cavity, is internal to the deep epigastric artery, and *oblique*, because it has to descend through the lower two-thirds of the inguinal canal. The course of this variety is as follows: the hernia enters the middle inguinal fossa, elongating before it the peritoneum forming that fossa. It then passes through the outer third of Hesselbach's triangle and descends through the lower two-thirds of the inguinal canal, from which it emerges through the external abdominal ring into the scrotum, thus forming a complete internal oblique inguinal hernia. Practically the only difference between the course of an internal oblique and an external oblique inguinal hernia is that the external oblique variety enters the inguinal canal by its natural inlet, namely, the internal abdominal ring, whereas the internal oblique variety obtrudes itself into the upper part of the inguinal canal through its posterior wall. It is to be noted (1) that there is no natural opening in the fascia transversalis over the outer third of Hesselbach's triangle, as there is external to the deep epigastric artery, and (2) that there is no conjoined tendon over the outer third of Hesselbach's triangle. The coverings of this variety, enumerated in order from within outwards, are as follows:

1. Parietal peritoneum.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis.
4. Cremasteric or middle spermatic fascia.
5. Intercolumnar or external spermatic fascia.
6. Tunica dartos.
7. Skin.

If the coverings of an external oblique, and an internal oblique, inguinal hernia are compared with each other, it will be seen that the former has a tube of fascia transversalis already prepared for it, namely, the infundibuliform fascia, whereas the latter has to elongate before it a fresh portion of fascia transversalis. In some cases the fascia transversalis over the outer third of Hesselbach's triangle is covered by an expansion from the conjoined tendon, which is known as the reflected tendon of Cooper. In such cases that reflected tendon must be added as a covering of internal oblique inguinal hernia, its position being immediately superficial to the covering formed by the fascia transversalis. The relation of an internal oblique inguinal hernia to the spermatic cord is similar to that of an external oblique, and the possible seats of stricture are also similar. The neck of the sac is the most common situation, and the deep epigastric vessels lie immediately on its *outer* side. The extreme difficulty which must be experienced in diagnosing between an external oblique and an internal oblique hernia is explained by the fact that the former leaves the abdominal cavity immediately external to the deep epigastric vessels, and the latter immediately internal to them. Hence, the practical rule followed in operating is to cut upwards and not transversely. The propriety of this rule is further enhanced if it be remembered that an external oblique inguinal hernia of old standing may so drag upon the internal abdominal ring as to displace it downwards and inwards to a point behind the external ring, and thus a hernia which is really external oblique may simulate one of the internal direct variety.

Varieties of External Oblique Inguinal Hernia.—There are two varieties of this form of hernia, the special features of which depend upon abnormal conditions of the processus vaginalis (see p. 634). These varieties are named congenital and infantile.

Congenital Hernia.—There are two forms of congenital hernia. (1) The processus vaginalis may remain permanently open throughout, in which case the bowel descends within that process into the cavity of the tunica vaginalis at its lower extremity. The tunica vaginalis thus represents the

sac of the hernia, and this form is therefore spoken of as a **hernia into the tunica vaginalis.** In such cases the bowel more or less completely envelops the testis. (2) The processus vaginalis may be shut off only just above the testis, the part above this remaining as a funicular process communicating above with the general peritoneal cavity. In such cases the bowel descends into the funicular process, which thus forms the sac of the hernia. This form is therefore spoken of as a **hernia into the funicular process.**

Infantile Hernia.—There are two forms of infantile hernia, **infantile hernia proper** and **encysted hernia.** In both there is a funicular process which is closed *above*, towards the internal abdominal ring. It may also be closed below just above the testis, being thus distinct from the tunica vaginalis, or it may simply be an upward extension of the tunica vaginalis. In either case it is situated in front of the spermatic cord. In **infantile hernia proper** the bowel, having elongated the parietal peritoneum to form a sac, descends between the spermatic cord and the funicular process. Its importance consists in the fact that, before the bowel can be exposed in operating, *three serous layers* must be divided, two of these belonging to the funicular process and the other representing the wall of the hernial sac. In this form the descent of the bowel is arrested at the upper part of the testis. In **encysted hernia** the bowel, having elongated the parietal peritoneum to form a sac, pushes against the upper part of the funicular process so as to invaginate it in a downward direction in the form of a cup, in which the bowel, enclosed in its sac, lies. The condition of matters is therefore very much like an egg set in its cup, assuming that the top of the shell is removed, and that the wall of the cup is formed of two layers. To bring out this simile, the contents of the egg may be taken as representing the bowel, the shell of the egg being the sac of the hernia, and the assumed two layers of the wall of the cup representing the two serous layers of the doubled down or invaginated funicular process, the cavity thus formed representing the inside of the cup. In this form, as in infantile hernia proper, *three serous layers* must be divided before the bowel is exposed in operating, two of these belonging to the invaginated funicular process and the other representing the wall of the hernial sac.

Umbilical Hernia (Exomphalos).—By an umbilical hernia is meant a protrusion of bowel or of great omentum from the abdominal cavity through the umbilicus. The protrusion occurs through the *upper* part of the umbilicus, which, containing only the obliterated umbilical vein, is weaker than the lower part where the obliterated hypogastric arteries and the urachus lie. The coverings of an umbilical hernia are as follows:

1. Parietal peritoneum.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis.
4. An expansion from the decussating fibres of the aponeuroses of the abdominal muscles of opposite sides.
5. Superficial fascia.
6. The cicatricial cutaneous umbilical tissue.

There is no vessel liable to be injured in operating on this form of hernia, the deep epigastric artery being about 1½ inches from the linea alba.

The **congenital form** of umbilical hernia consists in a protrusion of bowel or omentum through the centre of the umbilicus into the umbilical cord, in which it may descend for some distance. Its possible presence will show the propriety of carefully examining the cord before ligaturing it after birth.

The anterior abdominal wall above the level of the umbilicus presents a median fold of parietal peritoneum, which represents a part of the upper border of the falciform ligament of the liver. This fold contains a portion of the obliterated umbilical vein, which is now spoken of as the round ligament of the liver. It extends upwards from the umbilicus to the interlobar or umbilical

notch on the anterior border of the liver, through which it passes to enter the umbilical fissure on the under surface of the viscus. As the round ligament ascends to the liver the peritoneum, within which it lies, is being gradually elongated in the form of two closely applied laminæ, which thus project to form a part of the falciform ligament. The apex of this ligament is therefore at the umbilicus.

The Tunica Vaginalis and Testis.

Tunica Vaginalis.—This is a closed serous sac, behind which the testis lies. It is composed of two layers, parietal and visceral. The **parietal layer** is known as the *tunica vaginalis scroti*, from the circumstance that it lines the scrotal chamber of its own side, and it is formed by the lower part of the processus vaginalis or peritoneal diverticulum, which precedes the descent of the testis from the abdominal cavity. It is much larger and looser than the visceral layer, with which it is continuous along the posterior border of the testis and on the spermatic cord about ½ inch above the organ. The **visceral layer** is known as the *tunica vaginalis testis*, and is

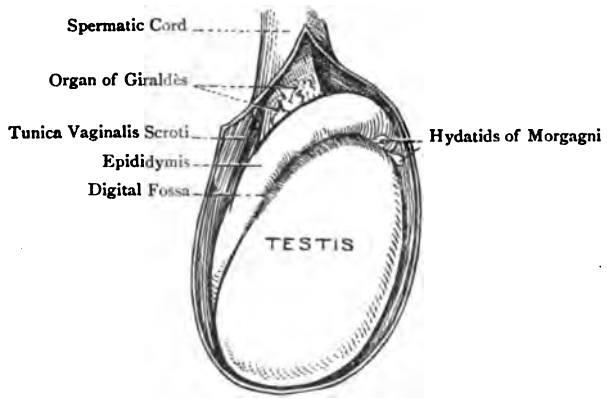


FIG. 286.—THE TESTIS AND ITS COVERINGS.

formed by the primitive peritoneum which covered the testis whilst in the abdominal cavity. It is also known as the *tunica adnata* ('born to'). It closely invests the tunica albuginea of the testis, to which it is inseparably united. It also invests the epididymis except at its posterior border, where the constituents of the spermatic cord enter or leave the testis. Between the epididymis and the testis it forms a recess, called the **digital fossa**, and it extends upwards on the spermatic cord for about ½ inch above the testis. Along the posterior border of the organ, where this layer becomes continuous with the parietal layer, there is a narrow

strip which is free from serous investment. The portion of the tunica vaginalis which is related to the spermatic cord is called the *funicular part.* When fluid accumulates between the parietal and visceral layers the condition is known as hydrocele of the tunica vaginalis.

Testis.—The testis is suspended obliquely by the spermatic cord in its scrotal compartment, to the bottom of which it is loosely attached by the fibrous remains of the gubernaculum testis. The left testis is a little lower than the right. The organ is oval, and compressed from side to side. Its exterior, which is smooth, is closely invested by the visceral layer of the tunica vaginalis, except where the constituents of the cord enter or leave the organ. The surfaces are external and internal, the former looking slightly backwards, and the latter forwards. The extremities are superior and inferior, the former being inclined forwards, and the latter backwards. The borders are anterior and posterior. The anterior border looks slightly downwards and outwards, and is free. The posterior border looks upwards and inwards, and is attached. The average weight of the testis is about 7 drachms.

Epididymis.—This is an elongated narrow body, composed of the convolutions of the excretory duct, and lying along the posterior border and adjacent portion of the external surface of the testis. Its upper extremity, which is above the upper end of the testis, is enlarged, and is called the **caput** or **globus major**; the lower and smaller end is called the **tail** or **globus minor**; and the intervening narrow portion represents the **body.** The globus major and globus minor are connected to the testis by fibrous tissue, and by a reflection of the tunica vaginalis, the former being further connected to the organ by the efferent ducts. The body, except at its posterior border, is free, being separated from the testis by the digital fossa. The epididymis is almost completely invested by the visceral layer of the tunica vaginalis except at its posterior border, where there is a duplicature of that membrane containing bloodvessels and attaching it to the testis.

Hydatids of Morgagni.—These are two small pyramidal bodies which are situated on the anterior aspect of the globus major at its lower part, or on the front of the upper end of the testis below the globus major, one of them being pedunculated and the other sessile. Each is composed of connective tissue and bloodvessels, covered by the visceral layer of the tunica vaginalis. The hydatids are vestiges of Müller's duct.

Organ of Giraldés or **Paradidymis.**—This organ is situated on the front of the spermatic cord, immediately above the globus major, and under cover of the funicular part of the tunica vaginalis. It consists of a few irregular nodules of convoluted tubules, which are lined with ciliated columnar epithelium. These nodules are remains of the Wolffian body.

Arterial Supply of the Testis and Epididymis.—The testis derives its arterial supply from the testicular branch of the spermatic

(which enters the posterior border of the organ), and the epididymis derives its supply from the epididymal branch of the spermatic, which vessel arises from the abdominal aorta about 1 inch below the renal artery. The globus minor of the epididymis also receives a few twigs from the deferential artery, which is usually a branch of the superior vesical from the internal iliac.

The **veins** of the testis issue at the upper part of the posterior border, and, along with those of the epididymis, enter the spermatic cord, where they form the pampiniform plexus. The *right* spermatic vein, in which the right plexus ultimately ends, opens directly into the inferior vena cava, and the *left* into the left renal vein.

Lymphatics.—These ascend in the spermatic cord, and accompany the spermatic vessels as high as the *median group of lumbar glands* in which they terminate.

Nerve-supply.—The spermatic plexus of the sympathetic system, which derives its fibres from the aortic and renal plexuses.

The testis is homologous to the ovary of the female (testis muliebris).

Abnormal Positions of Testis.—The testis may not be situated in the scrotum, its absence therefrom being due to one of three causes: (1) the testis may never leave the abdomen, or its descent may be arrested in the inguinal canal, such conditions being known as *cryptorchismus;* (2) instead of entering the scrotum, it may pass into the anterior part of the perineum; (3) it may leave the abdomen through the crural ring, and, after descending through the crural canal and passing through the saphenous opening, it may take up its position on the front of the thigh, where it might simulate a femoral hernia.

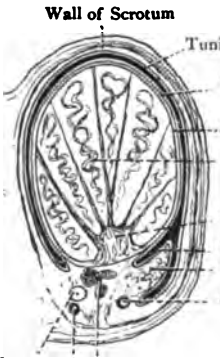


FIG. 287.—DIAGRAM SHOWING A TRANSVERSE SECTION OF THE TESTIS AND SCROTUM.

General Structure of the Testis and Epididymis.—The **testis** is an aggregation of seminiferous tubules collected into lobules, which are encased within a capsule called the *tunica albuginea*. This tunic is a dense, bluish-white, inelastic membrane, composed of bundles of fibrous tissue. Its outer surface is closely covered by the tunica vaginalis testis. Its inner surface is invested by a copious vascular network, known as the *tunica vasculosa of Cooper*. At the posterior border of the testis the tunica albuginea passes for a certain distance into the interior, this inflection being called the **corpus Highmorianum,** or **mediastinum testis.** This mediastinum extends into the organ for one-fourth of its antero-posterior measurement, and from its sides and anterior border a number of trabeculæ, containing plain muscular tissue, pass off, which extend in various directions as far as the inner surface of the tunica albuginea, to which they are attached. By means of these the interior of the testis is mapped out into a number of loculi, the trabeculæ which enclose them

containing the branches of the spermatic artery as they make their way to the tunica vasculosa. These compartments contain the **seminiferous tubules** collected into bundles, called the *lobuli testis*, which vary in number from 300 to 400. Each lobule contains from two to four tubules, and is conical, the base being directed towards the circumference of the testis and the apex towards the mediastinum. Each tubule is about $\frac{1}{120}$ inch in diameter, and is convoluted. When the coils are undone the tubule measures about 2 feet in length. The tubules of each lobule unite into one, and the tubules of adjacent lobules unite in turn, and so give rise to the *tubuli recti*, each of which is about $\frac{1}{300}$ inch in diameter, and about $\frac{1}{15}$ inch in length. These tubuli recti enter the mediastinum, where they form by their division a network, called the *rete testis*. From this rete tubules, called *vasa efferentia*, proceed, which are about $\frac{1}{60}$ inch in diameter, their number varying from twelve to twenty. These leave the testis at the upper part of its posterior border. For a short distance thereafter they remain straight, but they are soon thrown into convolutions, which form conical masses, called *coni vasculosi*. The length of each conus vasculosus is about $\frac{1}{2}$ inch, and its apex is directed towards the testis. When the convolutions are undone, the tube assumes a length of about 8 inches, its diameter gradually diminishing from about $\frac{1}{15}$ inch at its commencement to about $\frac{1}{60}$ inch at its termination. The coni vasculosi open by separate orifices into the canal of the epididymis.

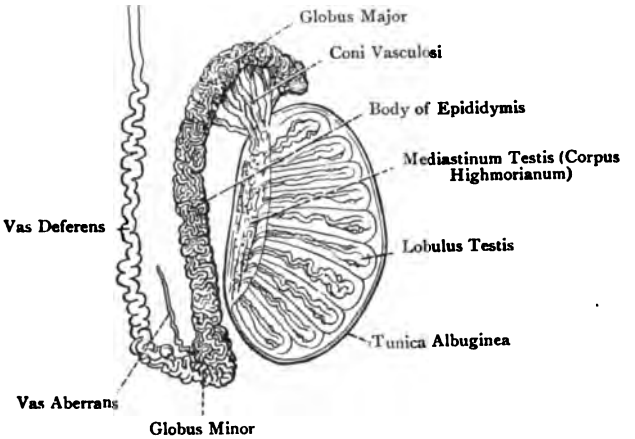


FIG. 288.—THE STRUCTURE OF THE TESTIS AND EPIDIDYMIS.

The **epididymis** consists of one tube, having a diameter of about $\frac{1}{15}$ inch in the globus major, where it commences in a blind extremity. In the body it diminishes a little in diameter, and in the globus minor it again enlarges. The tube presents a great number of convolutions, which, being folded upon themselves and connected together by loose tissue, give rise to a series of lobules. When the convolutions are undone the length of the epididymis has been variously estimated at from 12 to 20 feet. At its upper extremity it receives the coni vasculosi, and beyond the globus minor it terminates in the vas deferens. At the point where it terminates in the vas deferens there is a diverticulum connected with it, called the *vas aberrans of Haller*, which extends upwards in a convoluted manner between the epididymis and the adjacent part of the vas deferens. The vas aberrans, when the coils are undone, is from 8 to 12 inches in length.

Minute Structure.—The **tubuli seminiferi** are composed of a hyaline basement membrane, lining which there are several layers of epithelial cells. The most external layer is known as the *lining epithelium*, and is composed

of cubical cells. Some of these project inwards between the succeeding layers, and are called the *sustentacular cells*. The next layer is formed of large cells, called the *spermatogenic cells*, and these may form more than one layer. The nuclei of these cells show indications of division. The most internal layer, which immediately surrounds the lumen of the tubule, is composed of small cells, called the *spermatoblasts*, from which the spermatozoa are formed. These *spermatozoa* lie with their heads buried between the more deeply placed cells, and their long tails projecting free into the lumen of the tubule. The enlarged ends or heads of the spermatozoa, whilst they lie buried between the deeper cells, are connected with the sustentacular cells of the lining epithelium. The **tubuli recti** are composed of a basement membrane lined with a single layer of cubical epithelium. The **tubules of the rete testis** are destitute of a basement membrane, its place being taken by the connective tissue of the mediastinum. The lining membrane of the tubules consists of a single layer of cubical cells. The **vasa efferentia and coni vasculosi** are composed of a basement membrane, external to which there is a layer of plain muscular fibres arranged in a circular manner. The lining epithelium is of the ciliated columnar variety.

FIG. 289.—THE TUBULI SEMINIFERI OF THE TESTIS (MAGNIFIED).

The **structure of the epididymis** is similar to that of the vasa efferentia and coni vasculosi.

Development of the Testis.—In connection with the development of the testis the following embryonic structures fall to be described, namely, the Wolffian duct, the Wolffian body, and the germinal epithelium and genital ridge.

Wolffian Duct.—This duct is developed in connection with a portion of mesoblast situated between the paraxial mesoblast and the pleuro-peritoneal cavity, and known as the **intermediate cell-mass.** In the very early embryo (from the second to the third week) a longitudinal cord makes its appearance, which is formed by a segmentation of mesoblastic cells from the intermediate cell-mass. This cord is at first solid, and in close proximity to the epiblast, from which circumstance it is regarded by some authorities as being of epiblastic origin. It soon, however, acquires a lumen, and is then known as the Wolffian duct. The posterior or caudal end of this duct opens into the posterior (lower) portion of the ventral or uro-genital compartment of the cloaca (the common opening of the uro-genital ducts and hind-gut).

Wolffian Body.—This body takes the form of a number of tubes, called **segmental tubes,** which are developed in the mesoblast of the intermediate cell-mass, these tubes being transversely disposed at right angles to the Wolffian duct. They are at first solid, but each is subsequently provided with a lumen, and by one extremity they open into the Wolffian duct. The Wolffian body attains its greatest development about the eighth week.

Germinal Epithelium and Genital Ridge.—The peritoneal epithelium on the inner side of the Wolffian body and Wolffian duct undergoes a thickening and segmentation, and so forms what is known as the *germinal epithelium*; and the portion of mesoblast covered by it forms a ridge, called the *genital ridge*. The germinal epithelium increases in thickness, and its more deeply placed cells multiply and invade the genital ridge, where they lie embedded in groups. It is from these cell-groups in the genital ridge that the **seminiferous tubules** of the testis, with their several layers of lining cells, as well as the Graafian follicles and ova in the female, are developed. Preparatory to the formation of the seminiferous tubules the cells embedded in the genital

ridge become disposed in columns which anastomose with each other in a reticular manner. In the meshes of this network large cells make their appearance, known as the *primordial sperm cells*, which, after division and subdivision, ultimately lose their identity. The cell-columns now become converted into tubules, which represent the seminiferous tubules of the body of the testis. The other constituents of the testis, namely, the **tubuli recti, rete testis**, and **vasa efferentia**, are developed as outgrowths from the anterior segmental tubes of the Wolffian body, whilst the **coni vasculosi** are developed from those parts of the involved anterior segmental tubes which open into the Wolffian duct. The tubuli recti now join, and become continuous with, the seminiferous tubules, the junction taking place about the third month. The **epididymis** is developed from the *anterior* or *cephalic part* of the Wolffian duct, and the **vas deferens** and **common ejaculatory duct** are developed from the *posterior* or *caudal part*. The **vas aberrans of Haller** and the **paradidymis** or **organ of Giraldés** are persistent remains of the *more posterior tubes* of the Wolffian body which have not taken part in the development of the testicular tubules. The tunica albuginea of the testis and the interstitial stroma of the organ are developed from the mesoblastic connective tissue of the genital ridge. The **hydatids of Morgagni** are vestiges of *Muller's duct*.

ABDOMINAL CAVITY.

The abdominal cavity is somewhat ovoid, the vertical measurement greatly exceeding the transverse. Its superior boundary is formed by the diaphragm, which here presents a concave surface. The inferior boundary is formed by the levatores ani and coccygei muscles, covered superiorly by the visceral pelvic fascia and inferiorly by the anal fascia. This boundary is concave on its upper aspect. The superior and inferior boundaries, being fleshy, are capable of contracting and relaxing alternately. During contraction the diaphragm descends on each side, and the levatores ani ascend, thus diminishing the vertical measurement of the cavity. During relaxation the reverse takes place, the diaphragm ascending and the levatores ani descending, and so the cavity is increased in its vertical measurement. The anterior and lateral boundaries are partly osseous and partly musculo-aponeurotic. The osseous boundaries are formed by the lower ribs above, and the pelvis below. Elsewhere these boundaries are formed by the musculo-aponeurotic planes of the abdominal muscles. The posterior boundary is formed by the bodies and discs of the lumbar vertebræ, psoas magnus and quadratus lumborum muscles with their fascial investments, sacrum, and coccyx. The cavity is divided into two regions, the abdomen proper and the pelvis. The **abdomen proper** is limited below by the brim of the pelvis, and its visceral contents are the abdominal portion of the alimentary canal, with the exception of the pelvic colon and rectum, the liver, pancreas, spleen, kidneys, and suprarenal bodies. The **pelvis** is situated below the level of the brim, and contains the pelvic colon, rectum, and internal uro-genital organs.

Abdomen Proper.

Division into Regions.—The abdomen proper is divided into nine regions by means of two horizontal and two vertical lines, with their

corresponding planes. The horizontal lines are called subcostal and intertubercular. The **subcostal line** encircles the abdomen proper on a level with the lowest parts of the tenth costal cartilages, and the plane corresponding to it is called the **subcostal plane**. The **intertubercular line** connects the highest points of the iliac crests which can be felt from the front, where there is usually a tubercle on the outer lip about 3 inches from the anterior superior iliac spine. The plane corresponding to this line is called the **intertubercular plane**. The vertical lines are called the **Poupart lines**, right and left, and each extends vertically upwards from the centre of Poupart's ligament. The planes corresponding to these lines are known as the **Poupart planes**. The subcostal and intertubercular lines, with their corresponding planes, map out the abdomen proper into three horizontal zones, called subcostal, umbilical, and hypogastric. The two Poupart lines, with their corresponding planes, subdivide each of these zones into three regions, two lateral, right and left, and a central. The abdomen proper is thus eventually divided into nine regions, three in each of the three horizontal zones, as follows: the **subcostal zone** is subdivided into *right hypochondriac*, *epigastric*, and *left hypochondriac regions;* the **umbilical zone** is subdivided into *right lumbar*, *umbilical*, and *left lumbar regions;* and the **hypogastric zone** is subdivided into *right iliac*, *hypogastric*, and *left iliac regions*.

Superficial View of the Contents.—On taking a superficial view of the contents of the abdomen proper the sharp anterior border of the liver is seen on the right side projecting beyond the right costal margin, and also beyond the ensiform process. The great bulk of the organ, however, lies concealed in the right hypochondrium, and the extent to which it passes into the left hypochondrium usually corresponds to the left mammary line. In the middle line it projects beyond the ensiform process for about 2 inches, but along the right costal margin it does not usually project more than about $\frac{1}{2}$ inch. The anterior border presents two notches. One, which is well defined, is called the **interlobar** or **umbilical notch.** It is situated fully 1 inch to the right of the middle line, and transmits the obliterated umbilical vein or round ligament. The other, which is situated about 2 inches to the right of the interlobar notch, is usually somewhat indefinite, and is called the **cystic notch.** It allows the fundus of the gall-bladder to come forward opposite the ninth right costal cartilage at a point coinciding with the outer border of the right rectus muscle. The falciform or suspensory ligament is conspicuous as it takes attachment to the supero-anterior surface of the liver, which it divides into two lobes, right and left.

On the left side a portion of the stomach is visible, though a large part of the viscus lies deeply in the left hypochondrium. The portion which is seen in the epigastrium is partially covered by the left lobe of the liver, but a part of it is in contact with the anterior abdominal wall, provided the viscus is not empty.

Descending from the great curvature of the stomach there is an extensive fold of peritoneum, which hangs down in the form of a curtain, and so conceals the subjacent viscera. This fold is called the **great** or **gastro-colic omentum.** In normal circumstances it descends as low as the level of the sacral promontory upon the left side, but it stops a little short of that level on the right side. The condition of the great omentum is subject to much variety. In some bodies it is very narrow, and much puckered in the vertical direction, so as to leave exposed the viscera which are normally covered by it. In other cases it is displaced to one or other side, or it may even be raised into the left hypochondrium. In normal circumstances a few coils of the ileum are visible beyond the great omentum on the right side, and, more especially in the female, one or two loops may descend into the pelvic cavity to occupy the pouch of Douglas. In the right iliac fossa the cæcum is in part seen, and in the left iliac fossa the iliac colon is partially visible.

When the great omentum is raised and laid over the costal margin the coils of the jejunum and ileum come into view, occupying the umbilical and hypogastric regions, and extending into the right and left lumbar, and iliac, regions. The transverse colon is also seen crossing in an arched manner from the right to the left hypochondriac regions.

Position, Connections, and Component Parts of the Stomach.—The stomach occupies a very oblique position, its direction being downwards and to the right. It is situated in the left hypochondrium, within the left costal margin, and also in the epigastrium, the extent to which it encroaches upon the latter region varying according to the degree of distension of the organ. The liver and diaphragm are partly above and partly in front of it, the transverse colon being immediately below it. The viscus has the form of a curved cone, the base being directed upwards and to the left, and the apex downwards and to the right. The right extremity is bent slightly upwards and backwards. The component parts of the stomach are as follows: two extremities, two surfaces, two borders, and two orifices.

The **extremities** are left and right. The **left extremity** is also called the *cardiac* or *splenic end.* It is much enlarged, and lies deeply in the left hypochondrium within the left costal margin. This end forms the *fundus* or great cul-de-sac, and when distended it pushes up the diaphragm, and so encroaches upon the space naturally occupied by the heart and left lung. The upward limit of this part towards the middle line is the sixth left chondro-sternal articulation, and in the left mammary line it reaches as high as the fifth rib behind and above the position of the apex-beat of the heart. The **right extremity** or *pyloric end* is bent slightly upwards and backwards, and presents a small dilatation, called the *antrum pylori* or small cul-de-sac. The pyloric end lies in the epigastrium, and may be overlapped by the quadrate lobe of the liver.

The **surfaces** are anterior and posterior, provided the viscus is empty, but, when it is fully distended, the anterior surface

becomes superior and the posterior surface inferior. In moderate distension the surfaces are antero-superior and postero-inferior. The **antero-superior surface** is in contact from left to right with the diaphragm, the anterior abdominal wall, and the left lobe of the liver. The **postero-inferior surface** corresponds with the crura of the diaphragm, aorta, inferior vena cava, pancreas, spleen, upper extremity of the left kidney, left suprarenal body, and transverse meso-colon.

The **borders** are upper and lower. The **upper border** is known as the **small curvature**, and its direction is upwards and to the right. It extends from the lower end of the œsophagus to the pylorus, and is concave, except near the pylorus, where it becomes

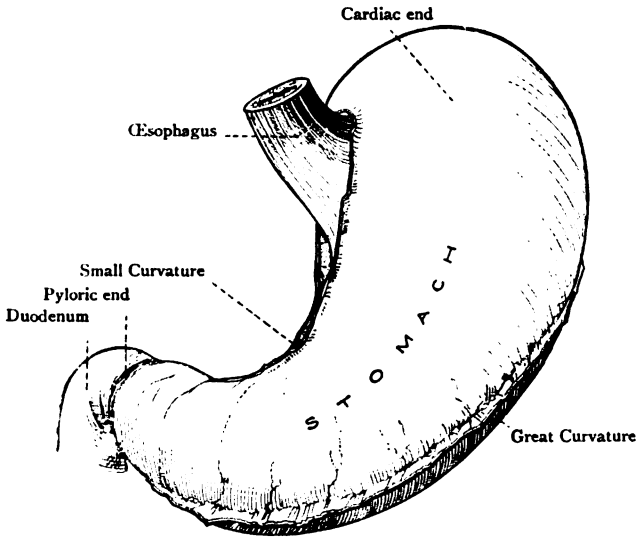


FIG. 290.—THE STOMACH (EXTERNAL VIEW).

convex as it enters into the formation of the antrum pylori. The gastro-hepatic omentum is attached to this border. The **lower border** is known as the **great curvature**, and its direction is downwards and to the left. It is convex, except near the antrum pylori, where it presents a concavity, and the gastro-colic omentum is attached to it.

The **orifices** are called cardiac and pyloric. The **cardiac orifice** or **cardia** is situated at the left end of the small curvature, and about 3 inches from the extreme left end of the viscus. It lies behind the seventh left costal cartilage at a point 1 inch to the left of the sternum, and, relatively to the vertebral column, it is about the level of the tenth or eleventh thoracic vertebra. The

pyloric orifice or **pylorus** is situated at the right end of the stomach, and is nearer the anterior abdominal wall, and on a lower level, than the cardiac orifice. Its position is ascertained by taking a point about 3½ inches below the junction of the body and ensiform process of the sternum, and just to the right of the linea alba. Relatively to costal cartilages it is on the level of a line connecting the tips of the ninth cartilages, and relatively to the vertebral column it is about the level of the twelfth thoracic or first lumbar vertebra.

In the empty state the stomach lies against the posterior wall of the abdomen, and, for an extent corresponding to the cardiac three-fourths, the viscus lies vertically, whilst the pyloric fourth is horizontal. The most movable part of the stomach is the pyloric extremity, the cardiac part being more or less fixed.

Peritoneal Relations.—The stomach is almost completely invested by peritoneum, the anterior surface deriving its covering from the peritoneum of the general cavity, and the posterior surface from that of the small sac. The parts uncovered by peritoneum are as follows: a narrow line along the small curvature between the two layers of the gastro-hepatic omentum for the passage of the gastric and pyloric arteries; a narrow line along the great curvature between the two layers of the gastro-colic omentum for the passage of the right and left gastro-epiploic arteries; and the **uncovered area or trigone.** This latter area is situated on the posterior surface, below, and a little to the left of, the cardiac orifice. It is about 2 inches in breadth, and rather less from above downwards, its shape being triangular. This part of the stomach is in contact with the left crus of the diaphragm, and sometimes with the left suprarenal capsule. The reflection of the peritoneum around this area from the stomach to the diaphragm is known as the gastro-phrenic ligament, which lies on the left side of the lower end of the œsophagus.

For the structure and development of the stomach, see pp. 733, 750.

Position, Connections, and Component Parts of the Intestinal Canal.—The intestinal canal commences at the pyloric end of the stomach and terminates at the anus. It is divided into small intestine and large intestine.

The **small intestine** commences at the pyloric extremity of the stomach, and terminates in the right iliac fossa by opening obliquely into the large intestine. It measures fully 20 feet in length, and is divided into three parts, which, from above downwards, are called the duodenum (twelve fingers' breadth), jejunum ('empty'), and ileum ('coiled'). The **duodenum** is from 10 to 11 inches in length, and its limits are the pyloric extremity of the stomach, and the left side of the body of the second lumbar vertebra. Being very deeply placed, its position and connections will be described further on (p. 685). Of the remainder of the small intestine the upper two-fifths represent the jejunum, and the lower three-fifths the ileum. There is no evident external mark of separation between the three divisions of the small intestine, so that they merge insensibly into each other; but there are internal characters which serve to distinguish these divisions. On the left side of the body of the second lumbar vertebra, where the duodenum terminates in the jejunum, the bowel describes a bend in a downward and for-

ward direction, called the **duodeno-jejunal flexure**, which is suspended from the left crus of the diaphragm by a fibro-muscular band, called the *musculus suspensorius duodeni*. The **jejunum** and **ileum** are very much convoluted, their coils being covered to a greater or less extent by the great omentum. They lie below the transverse colon, and occupy the umbilical, hypogastric, right and left lumbar, and right and left iliac regions. A few coils of the ileum sometimes dip into the pelvis, and when this occurs they occupy, in the female, the pouch of Douglas. The jejunum and ileum are attached to the vertebral column by a fold of peritoneum, called the mesentery proper, which contains their blood-vessels, nerves, and lymphatics, and which is of such a nature as to permit of great mobility in this part of the intestinal tube. They are surrounded by peritoneum except along a narrow interval corresponding with the attachment of the mesentery proper, this border of the bowel being called the attached or *mesenteric border*, as distinguished from the free or *anti-mesenteric border*. The small intestine is a smooth cylindrical tube, which gradually diminishes in size from above downwards. The terminal portion of the ileum, as it is about to join the large intestine, is directed upwards and to the right, with a slight inclination backwards.

Meckel's Diverticulum.—This is a protrusion which is sometimes found connected with the free or anti-mesenteric border of the ileum about 3 feet above the ileo-cæcal valve. It represents the persistent proximal part of the **vitelline** or **vitello-intestinal duct,** which connects the yolk-sac with that portion of the primitive alimentary canal from which the lower part of the ileum is formed. It usually measures from 2 to 3 inches in length, and its calibre generally corresponds with that of the tube from which it springs. In most cases it resembles the finger of a glove, but occasionally it is reduced to the condition of a cord. It is rarely provided with a mesentery.

The **large intestine** commences in the right iliac fossa, and terminates at the anus. It measures about 6 feet in length, and gradually diminishes in size from its commencement to its termination. It is composed of the colon and the rectum. The **colon** is subdivided into the cæcum (with the vermiform appendix), ascending or right colon, hepatic flexure, transverse or middle colon, splenic flexure, descending or left colon, iliac colon, and pelvic colon.

Cæcum.—The cæcum (caput cæcum coli) is the commencement of the large intestine. It represents that part of the gut which extends below the ileo-cæcal orifice, and is situated in the right iliac fossa, where it rests upon the ilio-psoas muscle with the intervention of the fascia iliaca. Its lower end or fundus has an inclination inwards towards the pelvic brim, close to which it usually lies. The average length of the cæcum is about 2½ inches, its breadth being about 3 inches. When empty it is more or less covered by coils of the ileum. In the distended state it comes into contact with the anterior abdominal wall, and at the same time it descends as low as the outer half of Poupart's ligament. At its inner and back part, at a point about 2½ inches from its

lower end, it receives the termination of the ileum, the opening being guarded by the ileo-cæcal valve. The position of this valve corresponds with a point in the right spino-umbilical line between 1½ and 2 inches from the anterior superior iliac spine (*McBurney's point*). In normal cases the cæcum is very movable, being completely covered by peritoneum. The line of reflection of the peritoneum posteriorly may correspond with the level of the ileo-cæcal orifice. In some cases, however, the peritoneum, after having invested the posterior aspect of the cæcum, gives a covering to the posterior wall of the ascending colon for 1¾ inches (Treves), after which the reflection takes place. The line of reflection may be transverse or oblique, and the peritoneum so reflected is continuous with the left or inferior layer of the mesentery proper.

In a few cases (about 6 per cent.) the upper part of the posterior surface of the cæcum is destitute of peritoneum, and is bound down by connective tissue to the subjacent fascia iliaca. Under these circumstances its mobility is more or less curtailed.

Varieties of Cæcum.—The cæcum is characterized by extreme variableness as regards form, but the variations may be grouped into the following four principal types (Treves):

First Type.—In the fœtus the cæcum is conical, the vermiform appendix springing from the apex of the cone. The three longitudinal muscular tæniæ are disposed as follows: one is situated on the postero-internal aspect; a second lies along the postero-external aspect; and the third is placed on the anterior aspect. They are nearly equally distant from each other, and meet at the apex of the cæcum.

Second Type.—The cæcum is quadrilateral. The lower end presents two sacculi, and the vermiform appendix springs from the interval between them. The tæniæ are situated as in the preceding type.

Third Type.—In this variety the part of the cæcum to the *right* of the anterior tænia becomes more developed, and consequently more prominent, than the part to the left of that band, and the anterior wall undergoes greater growth than the posterior wall. During these changes the apex is being gradually shifted backwards and to the left, until finally it takes up a position near the ileo-cæcal junction, where it corresponds with the origin of the vermiform appendix. The part to the right of the anterior tænia becomes so much developed, especially in a downward direction, as to give rise to a false apex. This is the most common form of cæcum, the origin of the appendix being transferred to the left and posterior aspect.

Fourth Type.—In this variety the part to the *right* of the anterior tænia undergoes excessive development, and the part to the left becomes much atrophied, and in many cases practically disappears. This causes the anterior tænia to terminate at the lower part of the ileo-cæcal junction, and the vermiform appendix arises immediately posterior to that point.

Vermiform Appendix.—The vermiform appendix is a small diverticulum of the cæcum, which opens into its inner and back part rather more than 1 inch below the ileo-cæcal orifice. The cæcal end of the appendix is called its **base**, and the guide to it is rather more than 1 inch below McBurney's point. Its diameter corresponds with that of an ordinary goose-quill, and its length varies from 2 to 6 inches, or more. Its outline is serpentine, and the lumen is usually confined to its cæcal half, though it may extend throughout its entire length. The opening by which the appendix

communicates with the cæcum is occasionally guarded by a fold of mucous membrane, which is known as the **valve of Gerlach.** The appendix is provided with a mesentery, called the *appendicular mesentery* or *meso-appendix.* It seldom reaches more than half or two-thirds along the appendix, which latter is thus rendered more or less convoluted or serpentine. The meso-appendix and its variations will be found described on p. 672.

The position occupied by the appendix is extremely variable. According to Lockwood and Rolleston, the normal positions may be tabulated as follows:

1. The vermiform appendix often lies under the left or inferior layer of the mesentery, where it takes a course upwards and to the left in the direction of the spleen. (According to Treves this is its usual position.)
2. It may lie on the brim of the pelvis, or it may project into the pelvic cavity.
3. If the appendicular mesentery is long, the appendix may lie to the right of the cæcum and ascending colon, in which situation it may ascend over the right kidney towards the right lobe of the liver.
4. It may lie free over the cæcum and ascending colon.
5. It may lie free underneath the cæcum. (This is the second most common situation according to Treves.)

As regards abnormal positions of the vermiform appendix, it may, amongst other situations, be found lying in the retro-cæcal, or in the ileo-cæcal, fossa. It has been found extending horizontally across the vertebral column at the level of the lumbo-sacral angle, with its tip resting on the left psoas magnus muscle (Treves).

Ascending or **Right Colon.**—This extends from the cæcum, on a level with the ileo-cæcal orifice, to the under surface of the right lobe of the liver at a point to the right of the gall-bladder. Here it describes a bend, called the hepatic flexure, which indents the liver, and so gives rise to the impressio colica. The ascending colon occupies a part of the right iliac, right lumbar, and right hypochondriac regions, in which it lies deeply, being in contact with the posterior abdominal wall. Posteriorly it rests upon a portion of the right iliacus muscle covered by the fascia iliaca, the right quadratus lumborum invested by its sheath, and the front of the right kidney in its lower and outer part. Anteriorly it is more or less covered by the coils of the jejunum and ileum. Internally, it has the coils of the jejunum and ileum, and the right psoas magnus muscle, covered by its fascia. The ascending colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the ascending meso-colon. Occasionally a peritoneal fold is met with, which extends from the right side of the ascending colon to the abdominal wall at, or a little above, the level of the iliac crest. It is called the *sustentaculum hepatis*, and occurs in about 18 per cent. of cases (Treves). It presents anteriorly a free concave border, and it measures about 1½ inches in width, and about 2 inches from before backwards.

Hepatic Flexure.—This is the bend formed by the gut between

the termination of the ascending colon and the commencement of the transverse colon. The bend takes place in a direction forwards and to the left, and so brings the bowel in front of the second or vertical part of the duodenum. The hepatic flexure has the impressio colica on the inferior surface of the right lobe of the liver above it, the sharp anterior margin of the liver on its outer side, and the second part of the duodenum on its inner side. Posteriorly it is in contact with the right kidney in the same locality as the upper part of the ascending colon, and it is here uncovered by peritoneum.

Transverse or **Middle Colon.**—This, which is comparatively long and very arched, commences in the right hypochondrium in front of the second part of the duodenum, and terminates in the left hypochondrium in the splenic flexure. Its extremities are deeply placed, the right being a little lower and more superficial than the left, and both being comparatively fixed on account of the shortness of the transverse meso-colon at these points. The greater part of it descends into the umbilical region, where it usually lies just above the umbilicus. The transverse colon is completely invested by peritoneum, except occasionally for 1 inch or more posteriorly at its right extremity. The serous membrane forms an extensive fold behind it, called the *transverse meso-colon*, which passes backwards to the anterior border of the pancreas, and is of very limited extent at its right and left extremities. The transverse colon is covered in front by the great omentum. Above it, from right to left, are the liver, gall-bladder, great curvature of the stomach, inferior surface of the pancreas, and basal surface of the spleen; behind it are the second part of the duodenum, head of the pancreas, and transverse meso-colon; and below it are the coils of the jejunum.

Splenic Flexure.—This is situated in the left hypochondrium in contact with the basal surface of the spleen, and behind the cardiac end of the stomach. It occupies a higher and deeper position than the hepatic flexure, and its posterior surface is uncovered by peritoneum. Connected with its left aspect there is a triangular fold of the serous membrane, which attaches it to the diaphragm opposite the tenth or eleventh left rib. This fold is called the *phreno-colic* or *costo-colic ligament*, and it forms a platform upon which the basal surface of the spleen rests: hence the name *sustentaculum lienis* ('support of the spleen'). It will be found described on p. 675.

Descending or **Left Colon.**—This, which is of comparatively small calibre, commences in the left hypochondrium at the splenic flexure, and terminates in the lower part of the left lumbar region on a level with the back part of the iliac crest, where it passes into the iliac colon. It lies deeply in the left hypochondriac and left lumbar regions, being directed at first downwards and slightly inwards, and subsequently vertically downwards. Posteriorly it is in contact, from above downwards, with the front of the left kidney at its lower and outer part, and the left quadratus lumborum muscle invested by its sheath. Anteriorly it is covered by coils

of the jejunum and ileum. Internally coils of the jejunum and ileum form a superficial relation, whilst more deeply there are the lower part of the left kidney and the left psoas magnus muscle covered by its fascia. The descending colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the *descending meso-colon.*

The ascending, transverse, and descending parts of the colon form an arch, within the concavity of which the coils of the jejunum and ileum are disposed.

Iliac Colon.—This commences at the lower extremity of the descending colon on a level with the back part of the iliac crest, and terminates at the inner border of the left psoas magnus, anterior to the left sacro-iliac articulation. At this point it enters the pelvic cavity and becomes the pelvic colon. It is situated in the left iliac fossa, where it lies upon the ilio-psoas muscle with the intervention of the fascia iliaca, its direction being downwards and inwards. Anteriorly it is covered, when empty, by coils of the ileum, but when distended it lies in contact with the anterior abdominal wall. The iliac colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the *iliac meso-colon.*

For the **pelvic colon** and **rectum**, see p. 804.

The large intestine, with the exception of the vermiform appendix and rectum, is characterized by well-marked sacculations, which present a striking contrast to the smooth cylindrical contour of the wall of the small intestine. These sacculations are due to the longitudinal muscular fibres being gathered into three longitudinal bands, called *tæniæ coli* (ligaments of the colon), which are shorter than the portion of bowel to which they are applied. The sacculations are separated from each other by constrictions filled with fat. Another characteristic of the greater part of the large intestine is the presence, at frequent intervals, of small projections of the peritoneal coat containing fat, called *appendices epiploicæ.* These characteristics will be found described in connection with the structure of the large intestine on p. 746.

For the structure and development of the intestinal canal, see pp. 739, 751.

Position, Connections, and Component Parts of the Spleen.—The spleen (lien) is a ductless gland which lies deeply in the left hypochondrium opposite the ninth, tenth, and eleventh ribs, and extending from about the level of the ninth thoracic spine to that of the eleventh. The organ can only be seen when the stomach is drawn out from the left hypochondrium. It is soft, spongy, easily torn, and exceedingly vascular, and it has a dark red colour. It is so liable to become enlarged that it is subject to much variety as regards dimensions and shape. The following statement, therefore,

of its dimensions is only to be accepted as approximately accurate. The average length of the spleen may be said to be about 5 inches, its breadth, at the widest part, being about 3 inches, and its thickness about 1½ inches. The weight, which is very variable, is about 6 ounces. The organ occupies an oblique position, its long axis being directed downwards, outwards, and forwards. Its lower two-thirds are situated in the left hypochondrium, and the upper third in the epigastrium. When it has been hardened *in situ* its shape resembles that of an irregular tetrahedron (Cunningham)—that is to say, it resembles a solid figure enclosed by four equilateral triangles. The following description is based upon this view of its shape.

Apex.—This corresponds with the upper end, and lies in the epigastrium, about 2 inches from the median line. It is directed upwards, inwards, and slightly forwards.

Surfaces.—One aspect of the organ is directed towards the diaphragm, the other looking towards the abdominal cavity and its viscera. The former aspect represents the parietal or external surface, which is convex, and adapts itself to the concavity of the diaphragm. It is called the **phrenic surface,** and its direction is outwards, backwards, and upwards. It is in contact with the diaphragm opposite the ninth, tenth, and eleventh ribs, the left pleural sac descending for some distance between that part of the diaphragm and the adjacent ribs. A part of the base of the left lung, very thin and covered by pleura, also descends for a short distance so as to intervene between the upper part of this surface of the spleen and the exterior. The abdominal or visceral aspect is complex, and presents three surfaces, which are separated from each other by more or less well-marked ridges, radiating from the internal basal angle (Cunningham). These surfaces are called gastric, renal, and basal.

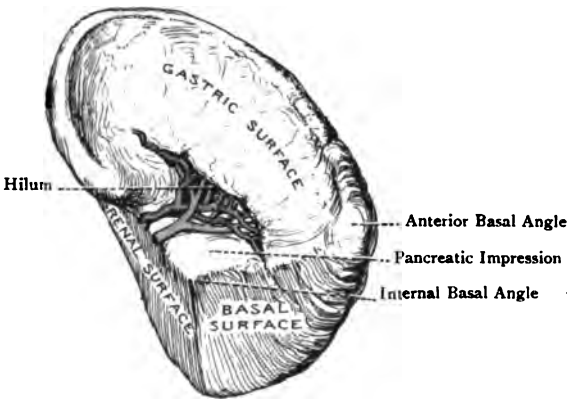


FIG. 291.—THE SPLEEN (VISCERAL AREÆ).

The **gastric surface** is large, concave, and somewhat semilunar. Its direction is forwards, inwards, and downwards, and it accurately adapts itself to the fundus of the stomach on its posterior aspect. It is limited anteriorly by the sharp anterior border of the spleen, which separates it from the phrenic surface, and

posteriorly it is separated from the renal surface by the ridge which extends from the internal basal angle upwards to the apex. A little in front of this ridge, and therefore situated on the gastric surface, there is a fissure, called the **hilum,** for the passage of the splenic vessels, lymphatics, and nerves. Instead of a hilum there is sometimes a row of foramina. The narrow portion of the gastric surface behind the hilum is, at its lower end, in contact with the tail of the pancreas.

The **renal surface,** which is posterior to the gastric surface, is narrow. It is directed inwards and downwards, and is in contact with the front of the left kidney at its upper and outer part, close to the external border. It is separated from the gastric surface by the ridge already referred to, and is limited behind by the posterior border, which separates it from the phrenic surface. Inferiorly it is separated from the basal surface by the ridge which extends from the internal basal angle to the posterior angle.

The **basal surface** is the small triangular surface which looks downwards and inwards. It rests upon the splenic flexure of the colon and upper surface of the sustentaculum lienis or peritoneal platform formed by the costo-colic ligament. It is separated from the renal surface by the ridge already referred to, and from the gastric surface by the ridge which passes between the internal and anterior basal angles. The angles of this surface are called *internal*, *posterior*, and *anterior*, the last being the most prominent.

Borders. — These are anterior, posterior, and inferior. The anterior border is situated between the phrenic and gastric surfaces. It is sharp, and usually presents several notches. The posterior border is situated between the phrenic and renal surfaces. It is blunt, and its position and direction practically coincide with the lowest left intercostal space. The inferior border separates the phrenic and basal surfaces, and is somewhat sharp.

Peritoneal Relations.—The spleen is surrounded by peritoneum, except at the hilum, and where the gastro-splenic omentum and phreno-splenic ligament are connected with it. The serous membrane forms three folds, called gastro-splenic omentum, lieno-renal ligament, and phreno-splenic ligament. The **gastro-splenic omentum** is attached by one extremity to the gastric surface of the spleen just in front of the hilum, the other extremity being connected with the cardiac end of the stomach on its posterior aspect and the left border of the great omentum. The **lieno-renal ligament** is attached by one extremity to the gastric surface along the line of the hilum, the other extremity being attached to the front of the left kidney at its upper and outer part. The **phreno-splenic** or **lieno-phrenic ligament** extends between the spleen near its upper extremity and the contiguous part of the diaphragm.

Occasionally small accessory spleens, varying in number from one to twenty, are found in the gastro-splenic omentum in the neighbourhood of the hilum, or more rarely in the great omentum.

Area of Splenic Dulness.—This area is limited posteriorly by the mid-scapular line between the ninth and eleventh left ribs, and anteriorly by the mid-axillary line as it crosses the ninth, tenth, and eleventh ribs, or by a line connecting the left sterno-clavicular joint with the tip of the eleventh left rib. The length of the area is about 3 inches, and its breadth from 2 to 2½ inches.

For the structure and development of the spleen, see p. 762.

Position, Connections, and Component Parts of the Liver.—The liver (hepar), which is the largest gland in the body, occupies almost all the right hypochondrium, a great part of the epigastrium, and a small part of the left hypochondrium, in which latter direction it usually extends as far as the left Poupart plane. It is maintained in position by the following peritoneal ligaments: the posterior or coronary ligament, the right and left lateral or triangular ligaments, and the falciform or suspensory ligament.

Topography.—The size of the liver is such a variable factor that the following statement of its limits is only to be regarded as approximately accurate. In the right mammary line it extends from a point about ½ inch below the right nipple to a point about ½ inch below the tip of the bony part of the *tenth* right rib, being covered by the right ribs from the fifth to the tenth inclusive. In the mid-axillary line the right aspect of the organ extends from the *seventh* to the *eleventh* rib, and in the scapular line its superior and inferior limits are on a level with the *ninth* and *eleventh* thoracic spinous processes respectively, the ribs to which it is here related being the ninth, tenth, and eleventh. The **left limit** of the organ usually corresponds to the left Poupart plane. In mapping out the **upper limit** the middle line may be taken as the starting-point. In this situation the limit is indicated by a line crossing the sternum at the level of the *sixth* costal cartilages, this line being slightly arched downwards. The line should then be prolonged to the left, with a slight curve upwards, to a point about 2 inches to the left of the left border of the sternum. In continuing the line to the right it should be carried upwards so as to reach a point about ½ inch below the right nipple. The line, on being prolonged from this point towards the right side, must be carried slightly downwards so as to reach the mid-axillary line at the level of the *seventh* right rib. The **lower limit** of the organ extends from a point about ½ inch below the tip of the bony part of the *tenth* right rib to the left extremity of the line indicating the upper limit. The direction of the line indicating the lower limit is upwards and to the left.

Summary of Outline of Liver.—Commencing at a point about 2 inches to the left of the left border of the sternum, draw a line downwards and to the right to the left border of the sternum at the level of the sixth costal cartilage, next across the sternum with a slight curve downwards, then upwards and to the right to a point about ½ inch below the right nipple. From this point carry the line downwards and to the right as far as the seventh rib in the right mid-axillary line, then downwards and backwards to the ninth rib on a level with the ninth thoracic spine, whence the line is carried downwards to the

eleventh rib on a level with the eleventh thoracic spine. From this latter point the line should proceed forwards and slightly upwards to a point about ½ inch below the tip of the bony part of the tenth right rib, and finally upwards and to the left to reach the starting-point.

The liver is to a very large extent under cover of the lower ribs and costal cartilages of the right side, the ensiform process, and the sixth, seventh, and eighth, costal cartilages of the left side. It is accurately moulded on the under surface of the diaphragm, which separates it from the base of the right lung covered by pleura, and the heart enclosed in the pericardium. The thin marginal part of the base of the right lung, with its pleural investment, descends in the angular interval between the diaphragm and the thoracic wall, and so partially covers the liver, a relation which has to be borne in mind in percussing the organ. In the right mammary line the lung descends as low as the *sixth* rib, whilst the liver ascends to the upper border of the *fifth*. In the right mid-axillary line the lung descends as low as the *eighth* rib, whilst the liver ascends as high as the *seventh*. In the right scapular line (inferior angle of scapula) the lung descends as low as the *tenth* rib, whilst the liver ascends as high as the *ninth*. The liver comes nearest to the surface beyond the right costal margin and ensiform process. In the former situation it projects about ½ inch, and in the latter about 2 inches, and in each situation is in contact with the anterior abdominal parietes.

Various circumstances affect the position of the liver. During respiration, the liver descends in inspiration and ascends in expiration. In the horizontal posture it ascends, and in the sitting or upright posture it descends. In distension of the stomach and intestines, as well as in ascites, it ascends. In right hydro-thorax, hypertrophy of the heart, and hydro-pericardium it descends. Long-continued pressure, as in tight lacing, causes the liver to be displaced downwards. Finally, when the abdomen proper is encroached upon by the gravid uterus or by an ovarian tumour the liver is displaced upwards.

The liver has a reddish-brown colour, and presents for the most part a smooth surface. It is firm to the touch, but under pressure is friable, that is to say, easily crumbled. The dimensions of the organ can only be stated approximately. In the transverse direction (from right to left) it measures from 7 to 10 inches, the measurement from before backwards at its right extremity being about 6 inches, which also represents its vertical measurement at the thickest part of the right lobe. Its weight in the adult ranges from 45 to 60 ounces, or from 3 to 4 pounds, the weight in the female being rather less, and its relation to the body weight being in the proportion of one to forty in the adult. In early life the liver is proportionately larger than in the adult, and in a child at the period of birth its relation to the body weight is as one to twenty.

Surfaces.—These are superior, anterior, inferior, right lateral, and posterior. It is not to be supposed, however, that these surfaces are all clearly separated from one another by well-defined borders, only one margin being in reality distinct, namely, the anterior border, which has a very sharp outline.

The **superior surface** is markedly convex in its right portion, and accurately adapts itself to the concavity of the diaphragm with which it is in contact. To the left of this convex part there is a depression, called the *impressio cardica*, produced by the heart with the intervention of the diaphragm. To the left of this impression the superior surface again becomes convex, and adapts itself to the concavity of the left half of the diaphragm. The superior surface is separated from the posterior, anterior, and right lateral surfaces by round, somewhat indistinct, borders.

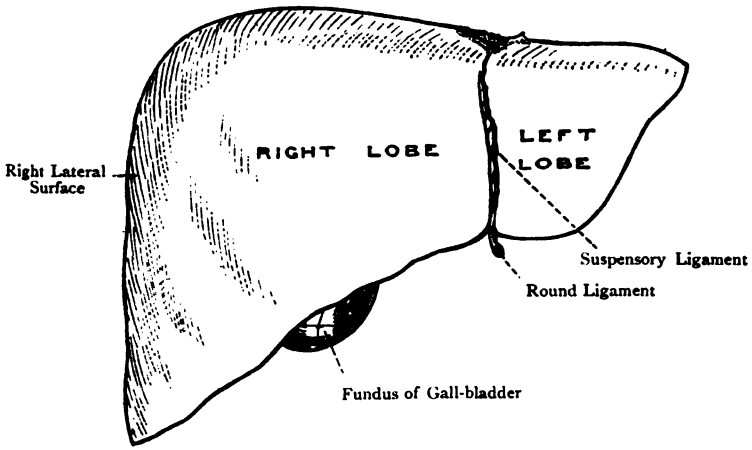


FIG. 292.—THE LIVER (ANTERO-SUPERIOR VIEW).

The **anterior surface** looks forwards and is triangular. The apex is directed towards the left extremity of the liver, whilst the base is towards the right extremity. One side of the triangle corresponds to the anterior border, the other side being formed by the round border which separates the anterior from the superior surface. The anterior surface is mainly in contact with the diaphragm and the right and left costal margins, but at the middle line it is in relation with the ensiform process, and, for about 2 inches below that process, it is in contact with the anterior abdominal wall. The superior and anterior surfaces are divided into two lateral parts by the falciform ligament, the part to the right of this ligament being called the **right lobe**, and the part to the left the **left lobe.** The right lobe forms about four-fifths of the entire supero-anterior surface in the adult, but in early life the two lobes are very nearly of equal size.

The **inferior surface** looks downwards with an inclination to the left. It is divided into two parts, right and left, by the umbilical fissure. The part to the left of this fissure represents a portion of the left lobe. It lies in front of the cardiac orifice

of the stomach, and the anterior surface of that organ close to the small curvature. The part related to the cardiac orifice presents an impression, called the *impressio gastrica*. The part to the right of this impression, close to the back part of the umbilical fissure, presents a smooth round eminence, called the *tuber omentale*. This eminence projects in a backward direction over the small curvature of the stomach, and so abuts against the anterior layer of the gastro-hepatic omentum : hence the name, tuber omentale. The part of the inferior surface to the right of the umbilical fissure presents, as its most striking object, the gall-bladder, which occupies the *cystic fossa*. This fossa extends from the anterior border to the

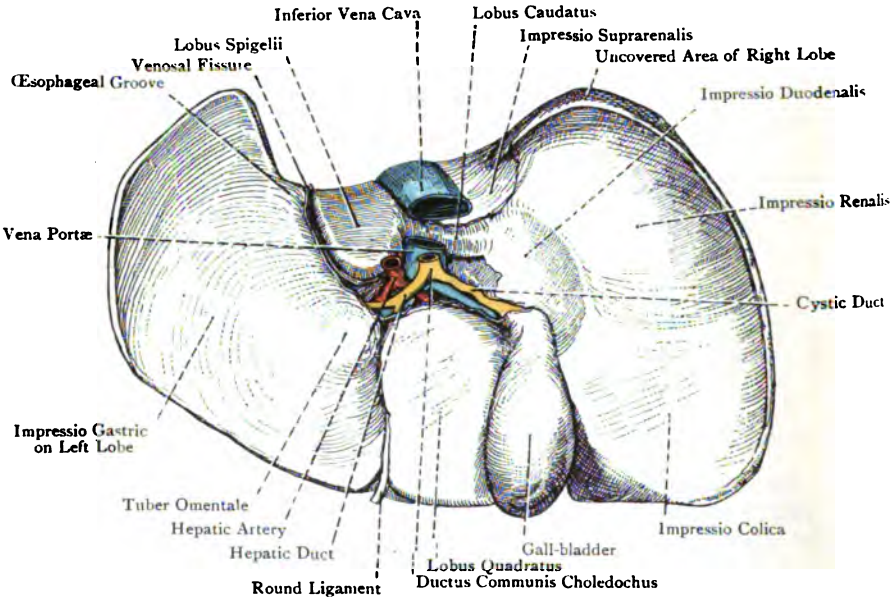


FIG. 293.—THE INFERIOR SURFACE OF THE LIVER.

portal or transverse fissure. It has the quadrate lobe on its left side, and a large part of the right lobe on its right side. The portion of the inferior surface of the right lobe to the left of the gall-bladder includes the following parts: the quadrate lobe, the portal or transverse fissure, the caudate lobe, and the lower margin of Spigel's lobe.

The *quadrate lobe*, which is elongated from before backwards, is bounded anteriorly by the anterior border of the liver; posteriorly, by the portal or transverse fissure; on the right side by the gall-bladder and cystic fossa; and on the left by the umbilical fissure. It is in contact with the pyloric end of the stomach and first part of the duodenum.

The *portal* or *transverse fissure* forms a right angle with the back part of the umbilical fissure, from which it extends over the inferior surface of the right lobe for a distance of about 2 inches. It is bounded in front by the quadrate lobe, and behind by the caudate lobe and the lower margin of Spigel's lobe. The two layers of the gastro-hepatic omentum are attached to its anterior and posterior lips. It serves for the passage of the following structures, in order from before backwards : (1) the hepatic duct ; (2) the hepatic artery, accompanied by the hepatic sympathetic plexus of nerves and lymphatic vessels ; and (3) the vena portæ, all surrounded by the capsule of Glisson.

The *caudate lobe* is the narrow portion of liver substance which connects the right extremity of the lower margin of Spigel's lobe with the adjacent part of the inferior surface of the right lobe. It lies behind the portal fissure, and has the vena portæ in front of it, and the inferior vena cava behind it. It forms the upper boundary of the foramen of Winslow.

The *lower margin of Spigel's lobe*, like the caudate lobe, is situated behind the portal fissure. It is divided by a notch into two eminences of unequal size. The right eminence, which is the smaller of the two, is continuous with the caudate lobe. The left eminence is of large size, and is known as the *tuber papillare*. The part of the inferior surface of the right lobe which lies to the right of the gall-bladder is of large extent, and presents three impressions, namely, impressio colica, impressio renalis, and impressio duodenalis. The *impressio colica*, which looks downwards, is situated in front, where it lies to the right side of the body of the gall-bladder. It is in contact with the hepatic flexure of the colon. The *impressio renalis*, which is of large size, looks backwards as well as downwards, is posterior to the impressio colica, and is in contact with a large part of the front of the right kidney. The *impressio duodenalis* is situated on the inner side of the impressio renalis, just external to the neck of the gall-bladder. It is in contact with the commencement of the second part of the duodenum.

The *umbilical fissure* is so named because it contains the remains of the umbilical vein, now known as the *round ligament of the liver*. It commences at the anterior border of the organ in the umbilical or interlobar notch, and extends as far back as the left extremity of the portal fissure, with which it forms a right angle. It separates the quadrate lobe from the inferior surface of the left lobe. Sometimes the fissure is more or less completely bridged over by a portion of hepatic substance, which thus forms a *pons hepatis*. The obliterated umbilical vein terminates by joining the left division of the vena portæ, and posteriorly the left division of the vena portæ is joined by the obliterated ductus venosus.

The **right lateral surface** is convex, and is in contact with the diaphragm and right ribs from the *seventh* to the *eleventh*, the margin of the base of the right lung and pleura here descending between the ribs and diaphragm as low as the *eighth* rib. There is

no well-marked line of demarcation between this surface and the posterior, superior, and anterior surfaces, but it is distinctly separated from the inferior surface by the right portion of the anterior border.

The **posterior surface** presents a concavity corresponding with the convexity of the bodies of the tenth and eleventh thoracic vertebræ. It is related to the diaphragm, and its component parts from left to right are as follows: the posterior part of the left lobe; the venosal fissure for the ductus venosus; Spigel's lobe, except its lower margin; the caval fossa for the inferior vena cava; and the uncovered area of the right lobe.

The *posterior part of the left lobe* at its left extremity is a mere margin, but elsewhere it presents a distinct surface marked by

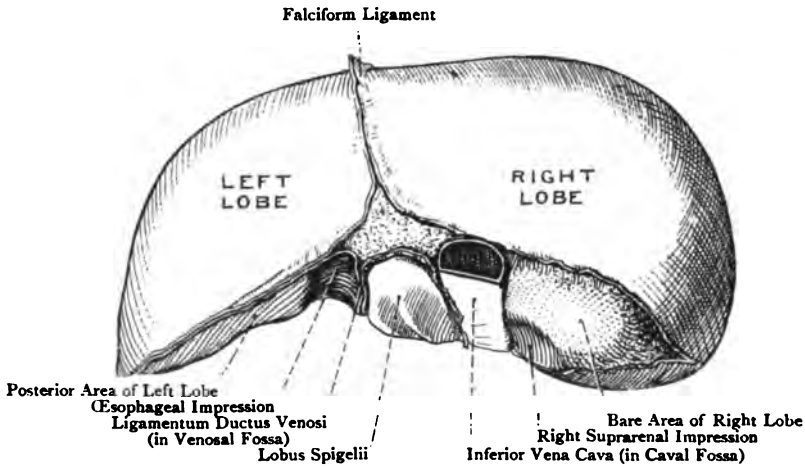


FIG. 294.—THE POSTERIOR SURFACE OF THE LIVER.

the *œsophageal groove*, which is in contact with the right side of the lower end of the œsophagus.

The *venosal fissure* lies vertically on the posterior surface, having Spigel's lobe on its right, and the œsophageal groove of the left lobe on its left. Inferiorly it meets the left extremity of the portal fissure and the posterior extremity of the umbilical fissure, and superiorly it meets the caval fossa. It lodges the obliterated ductus venosus, which is connected below with the left division of the vena portæ, and above with the inferior vena cava. The venosal and umbilical fissures separate the right and left lobes on the posterior and inferior surfaces respectively.

Spigel's lobe, with the exception of its lower margin, lies vertically on the posterior surface. It is bounded on the right side by the caval fossa, on the left by the venosal fissure, and inferiorly by the portal or transverse fissure. It looks backwards and a little

inwards, and is in contact with the right crus of the diaphragm opposite the tenth and eleventh thoracic vertebræ. Its lower margin has been already described (p. 661). The lobe lies at the upper end of the small cavity of the peritoneum.

The *caval fossa* lodges a part of the inferior vena cava. It lies vertically, and somewhat deeply, on the posterior surface, having the uncovered area of the right lobe on its right side, Spigel's lobe on its left side, and the caudate lobe below. This fossa is sometimes bridged over by a portion of liver substance, called a *pons hepatis*. At the upper part of this fossa the hepatic veins open into the inferior vena cava.

The *uncovered area* of the right lobe represents its back part. It measures from 2½ to 3 inches in the transverse direction, and fully 2 inches from above downwards, except at the extreme right, where it tapers to a point. It is destitute of peritoneum, and is enclosed between the two serous layers which form the coronary ligament, being attached to the diaphragm by areolar tissue. Its direction is backwards and a little inwards. The extreme left end of this area, at a point immediately to the right of the lower end of the caval fossa and near the caudate lobe, presents a somewhat triangular impression, called the *impressio suprarenalis*, for the right suprarenal body.

Borders.—The chief borders are three in number, namely, postero-superior, postero-inferior, and anterior. The *postero-superior* and *postero-inferior borders* give attachment to the two layers of peritoneum which form the coronary ligament, and they enclose between them the posterior surface. The *anterior border* is sharp. At its right extremity it passes backwards so as to separate the inferior from the right lateral surface. At its left extremity it also passes backwards, and so forms the thin left margin of the left lobe. Its anterior portion presents two notches, umbilical or interlobar and cystic. The *umbilical* or *interlobar notch* is situated fully 1 inch to the right of the middle line, and transmits the obliterated umbilical vein or round ligament. The *cystic notch*, often hardly perceptible, is situated about 2 inches to the right of the umbilical notch, and allows the fundus of the gall-bladder to come into contact with the anterior abdominal wall.

Peritoneal Relations.—The liver is covered by peritoneum except in the following regions: the uncovered area of the right lobe; a small triangular area at the posterior extremity of the hepatic attachment of the falciform ligament; the portal fissure; and the cystic fossa, unless in those cases where the gall-bladder is completely invested by peritoneum.

For the ligaments of the liver, see p. 673.

Excretory Apparatus of the Liver.—This consists of the hepatic duct, the gall-bladder, the cystic duct, and the common bile-duct.

The **hepatic duct** is formed by the union of a right and left branch which issue from the respective lobes at the portal fissure. It is the most anterior of the structures in that fissure, and, after

a course of rather more than 1 inch downwards and to the right, it joins the cystic duct, and so gives rise to the common bile-duct. The diameter of the hepatic duct is about $\frac{1}{6}$ inch.

The **gall-bladder** is a reservoir for the bile. It is pyriform, and is situated obliquely on the inferior surface of the right lobe, where it occupies the cystic fossa, having the quadrate lobe on its left side, and a large part of the right lobe on its right side. It extends from the anterior border of the liver to near the portal fissure, and presents a fundus, body, and neck. The *fundus*, which is round, looks downwards, forwards, and to the right. It occupies the cystic notch on the anterior border, and is in contact

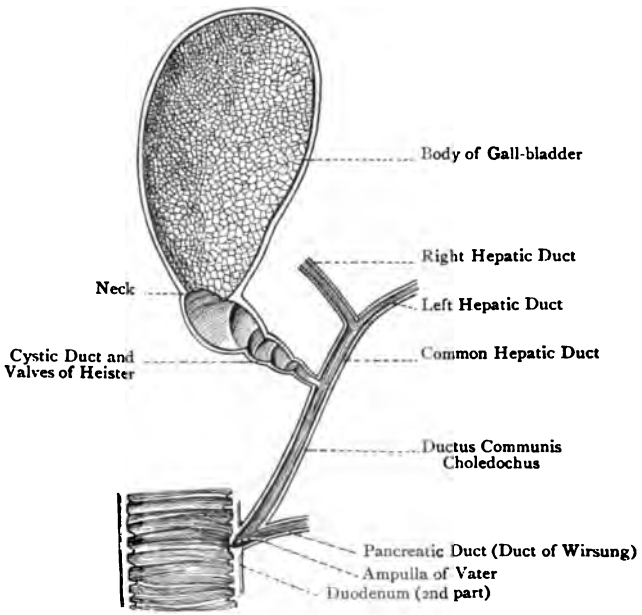


FIG. 295.—THE EXCRETORY APPARATUS OF THE LIVER.

with the anterior abdominal wall opposite the *ninth* right costal cartilage, at the outer border of the right rectus abdominis muscle. The *body* is directed upwards, backwards, and to the left. Its inferior and lateral surfaces are free, but superiorly it is attached by areolar tissue to the cystic fossa. It rests upon the right end of the transverse colon and the first part of the duodenum. The *neck* describes two curves like the letter S, after which it is continued into the cystic duct. The gall-bladder is usually covered by peritoneum, except on its upper surface. Sometimes, however, the serous membrane entirely surrounds it and forms a ligamentous fold above it, by which it is loosely and movably suspended

from the cystic fossa. The gall-bladder measures about 3 inches in length, its breadth at the widest part being 1½ inches. Its capacity is from 1 to 1½ ounces. For the structure of the gall-bladder, see p. 758.

The **cystic duct** is about 1½ inches long, its diameter being about $\frac{1}{12}$ inch. Its course is backwards, downwards, and to the left, and it ends by joining the hepatic duct near the portal fissure to form the common bile-duct.

The **common bile-duct** (ductus communis choledochus) is formed by the union of the hepatic and cystic ducts near the portal fissure. Its length is fully 3 inches, its diameter being about ¼ inch. It passes downwards between the two layers of the gastro-hepatic omentum in front of the foramen of Winslow, where it has the hepatic artery on its left side, and the vena portæ behind. It afterwards descends behind the first part of the duodenum, and subsequently between the second part of the duodenum and the head of the pancreas on their posterior aspect. It then enters the wall of the second part of the duodenum in company with the duct of the pancreas, and runs obliquely in the wall for ¾ inch. Thereafter it joins the pancreatic duct, and the resulting duct forms a dilatation, called the *ampulla of Vater*, which, having become constricted, pierces the mucous membrane and opens on the tip of the bile-papilla at the junction of the inner and posterior walls of the second part of the duodenum, where the upper two-thirds and lower third of that part meet. The distance of this opening from the pylorus is about 4 inches. The common bile-duct sometimes opens into the duodenum independently of the pancreatic duct, but close to it.

It is in the ampulla of Vater where a gall-stone may become lodged and delayed in its downward progress towards the duodenum.

Liver in Early Life.—The size of the liver in early life is much greater than in the adult, the left lobe in particular assuming large dimensions. As age advances, however, the left lobe undergoes a marked diminution in size.

For the structure and development of the liver, see pp. 753, 757.

Peritoneum.—The peritoneum is the serous membrane which lines the abdominal parietes, and invests more or less completely most of the viscera. It is composed of two layers, parietal and visceral, the contiguous surfaces of which are smooth and moist. In the male the interval between the two layers forms a shut sac, but in the female, at the fimbriated extremity of each Fallopian tube, the sac communicates with the lumen of that tube, and through it with the cavity of the uterus and the vagina. It is at the margin of the fimbriated extremity of each Fallopian tube where the endothelium of the peritoneum undergoes a sudden transition into the columnar ciliated epithelium of the Fallopian tube.

The peritoneum forms certain reflections or folds which are of three kinds, namely, omenta, mesenteries, and ligaments.

An **omentum** is *a double fold of peritoneum passing between two abdominal viscera.* The omenta are three in number, namely, the great or gastro-colic omentum (epiploön), which passes between the great curvature of the stomach and the transverse colon, the small or gastro-hepatic omentum, which passes between the small curvature of the stomach and the portal fissure of the liver, and the gastro-splenic omentum, which passes between the posterior surface of the cardiac end of the stomach and the gastric surface of the spleen.

A **mesentery** is a *double fold of peritoneum passing between a portion of intestine and the abdominal wall.* The mesenteries in the adult are normally as follows: the mesentery proper, which connects the jejunum and ileum to the vertebral column; the appendicular mesentery or meso-appendix, which is connected with the vermiform appendix; the transverse meso-colon, which extends between the transverse colon and the posterior wall of the abdomen at the anterior border of the pancreas; and the pelvic meso-colon, which connects the pelvic colon to the anterior surface of the sacrum as low as the third sacral vertebra. Occasionally the ascending colon, descending colon, and iliac colon are each provided with a mesentery, called respectively the ascending meso-colon, descending meso-colon, and iliac meso-colon.

A **ligament** is *a fold of peritoneum which connects a viscus not intestine to the abdominal or pelvic parietes.* The peritoneal ligaments are as follows: (1) the ligaments of the liver, namely, the falciform ligament, the coronary ligament, and the right and the left lateral or triangular ligaments; (2) the gastro-phrenic ligament; (3) the lieno-phrenic ligament; (4) the false ligaments of the urinary bladder, namely, two posterior, two lateral, and superior; and (5) the broad ligaments of the uterus.

Course of the Peritoneum.—The parietal and visceral layers of the peritoneum are in unbroken continuity with each other, and this continuity is shown by tracing the membrane in the vertical and transverse directions.

Vertical Course.—Commencing at the portal fissure of the liver two layers of peritoneum descend to the small curvature of the stomach, forming the gastro-hepatic omentum. On reaching the small curvature these two layers separate, one passing over the anterior surface, and the other over the posterior surface, of the stomach. At the great curvature they come together, and descend in the form of a curtain over the coils of the jejunum and ileum to the lower part of the abdomen, forming the two anterior or descending layers of the gastro-colic omentum. These two layers are then folded backwards and ascend to the transverse colon, thus forming the two posterior or ascending layers of the gastro-colic omentum. On reaching the transverse colon they separate, one layer passing in front of, and above, the bowel, and the other layer below and behind it. Having enclosed the transverse colon, the two layers meet, and are prolonged backwards to the posterior

wall of the abdomen at the anterior border of the pancreas, thus forming the transverse meso-colon. On reaching the anterior border of the pancreas the two layers of the transverse meso-colon take leave of each other, and form an ascending and a descending layer. The **ascending layer** passes upwards over the anterior surface of the pancreas, the second part of the duodenum, and the posterior portion of the under surface of the diaphragm,

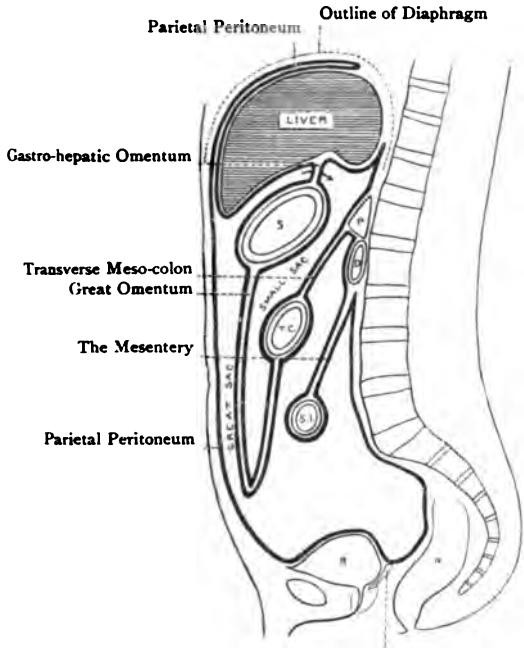


FIG. 296.—DIAGRAM OF THE PERITONEUM IN THE ADULT MALE (VERTICAL SECTION).

S. Stomach
P. Pancreas
D. Duodenum
T.C. Transverse Colon
S.I. Small Intestine
B. Urinary Bladder
R. Rectum

The arrow is through the Foramen of Winslow.

from which it passes to the postero-inferior border of the liver, thus forming the inferior layer of the coronary ligament. Having covered Spigel's lobe, it arrives at the posterior lip of the portal fissure, where it is continuous with the posterior layer of the gastro-hepatic omentum.

The **descending layer** of the transverse meso-colon passes at first backwards upon the inferior surface of the pancreas, and then downwards over the third part of the duodenum, at the lower border of which it is conducted off to the jejunum and ileum by the

superior mesenteric vessels. Having surrounded these portions of the small intestine it passes to the posterior abdominal wall upon the other aspect of the superior mesenteric vessels, and so forms the mesentery proper. It then descends over the abdominal aorta and inferior vena cava into the pelvis, where its course will be subsequently traced. From the apex of the urinary bladder this layer of the peritoneum is reflected on to the posterior surface of the anterior abdominal wall, after lining which it passes to the anterior portion of the under surface of the diaphragm, whence it is reflected on to the postero-superior border of the liver, thus forming the superior layer of the coronary ligament. It then passes over the superior and anterior surfaces of the liver, and, turning round its anterior border, it arrives at the anterior lip of the portal fissure, where it is continuous with the anterior layer of the gastro-hepatic omentum.

Transverse Course. — The peritoneum may be traced in the transverse direction at two levels, namely, above the transverse colon, or at the level of the foramen of Winslow, which is situated behind the right or free border of the gastro-hepatic omentum, and below the transverse colon, or at the level of the umbilicus.

Above the Transverse Colon, or *at the Level of the Foramen of Winslow.*—In front of the foramen of Winslow there are the two layers of peritoneum, anterior and posterior, which form the right or free border of the gastro-hepatic omentum, and which contain between them the common bile-duct, the hepatic artery, and the vena portæ. Tracing the gastro-hepatic omentum from this point to the left, its two layers separate to enclose the stomach, after which they pass to the gastric surface of the spleen as the gastro-splenic omentum. The two layers of this omentum are anterior and posterior, and they contain between them the vasa brevia of the splenic artery. At the spleen the two layers are immediately in front of the hilum. The anterior layer now takes temporary leave of the posterior layer, and turns completely round the spleen, covering its gastric, basal, phrenic, and renal surfaces in succession. On leaving the renal surface of the organ it again passes to the gastric surface, but it is now behind the hilum. Here it meets the posterior layer of the gastro-splenic omentum, which had remained meanwhile stationary immediately in front of the hilum. These two layers now pass backwards to the anterior surface of the left kidney at its upper extremity, and close to its external border, thus forming the lieno-renal ligament. The two layers of this ligament are disposed as right and left, and between them are the splenic branches of the splenic artery. The right layer corresponds with the posterior layer of the gastro-splenic omentum, and the left layer with the anterior layer of that omentum. The *right layer* of the lieno-renal ligament, after leaving the left kidney, passes to the right over the aorta and inferior vena cava. As it covers the latter vessel it is placed *behind* the foramen of Winslow.

It then continues its course to the right, and, having given a partial covering to the front of the right kidney, it passes over the right lateral and anterior wall of the abdomen as far as the middle line. The *left layer* of the lieno-renal ligament, after leaving the left kidney, passes over the left lateral and anterior wall of the abdomen, and, on arriving at the middle line, it becomes continuous with the right layer, which has just been traced as far as the middle line. Along the posterior surface of the anterior wall of the abdomen in the middle line, above the level of the umbilicus, the peritoneum meets with the obliterated umbilical vein or round ligament

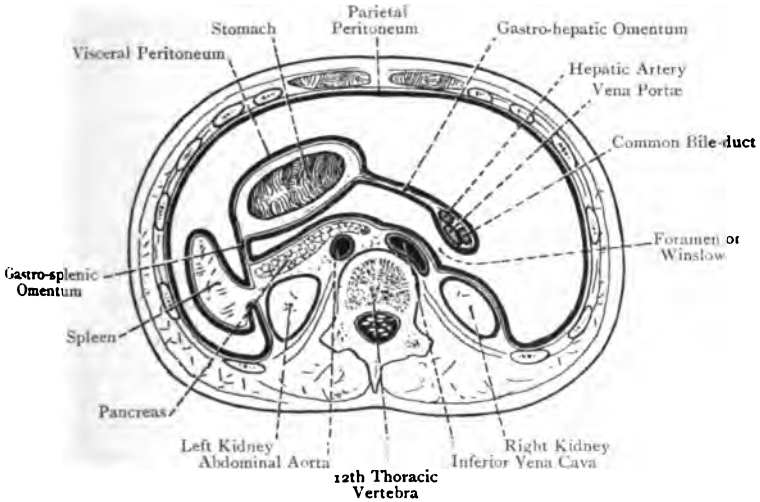


FIG. 297.—DIAGRAM OF THE PERITONEUM AT THE LEVEL OF THE FORAMEN OF WINSLOW (TRANSVERSE SECTION).

of the liver, around which it is reflected, and here it is carried off from the abdominal wall to form part of the falciform or suspensory ligament.

Another way to trace the peritoneum transversely at the level of the foramen of Winslow is to commence just behind that foramen. Beginning at this point, the peritoneum, which covers the inferior vena cava, passes to the right, and, having given a partial covering to the front of the right kidney, it is continued over the right lateral wall of the abdomen, and thence over the right half of the anterior wall. At the middle line, above the level of the umbilicus, it meets with the obliterated umbilical vein or round ligament of the liver, around which it is reflected, and here it is carried off from the abdominal wall to form part of the falciform or suspensory ligament. It then continues its course over the left

half of the anterior abdominal wall and the left lateral wall, whence it passes on to the front of the left kidney at the upper part, close to the external border. From this point it passes to the right over the posterior wall of the abdomen, covering the aorta and inferior vena cava, and so it arrives at a point behind the foramen of Winslow. Between the left kidney and the hilum of the spleen the peritoneum forms the lieno-renal ligament, and between the gastric surface of the spleen, just in front of the hilum, and the posterior aspect of the cardiac end of the stomach it forms the gastro-splenic omentum. The two layers of this omentum, having separated, enclose the stomach. They then meet at the small curvature to form the gastro-hepatic omentum, the layers of which, when followed to the right, arrive at the front of the foramen of Winslow.

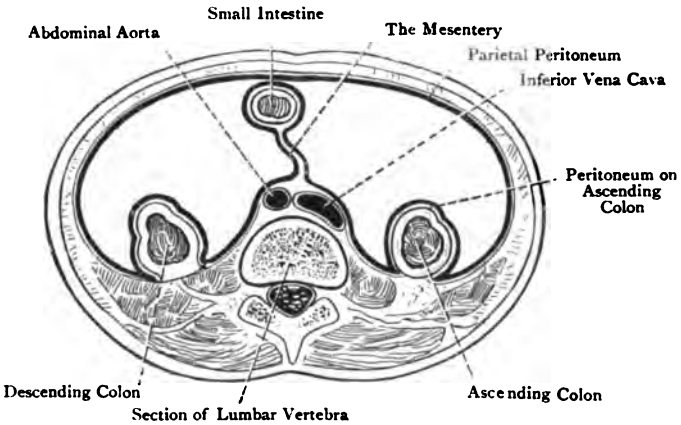


FIG. 298.—DIAGRAM OF THE PERITONEUM AT THE LEVEL OF THE UMBILICUS (TRANSVERSE SECTION).

Below the Transverse Colon, or *at the Level of the Umbilicus.*—Commencing at the middle line and passing to the right, the peritoneum covers the right half of the anterior abdominal wall and the right lateral wall as far as the lumbar region. It then covers the right side, anterior surface, and left side of the ascending colon, whence it passes over the front of the right kidney at its lower and inner part. Thereafter it is reflected over the inferior vena cava, and, meeting with the superior mesenteric vessels, it is carried off by them to the jejunum and ileum, both of which it invests. It is then conducted back again to the vertebral column by the superior mesenteric vessels, thus forming the mesentery proper. It next passes to the left over the aorta, and, having partially covered the front of the left kidney at its lower and inner part, it meets with the descending colon in the left lumbar region, which it covers on the right side, anterior surface, and left side. Thereafter it is

reflected over the left lateral and left half of the anterior wall of the abdomen as far as the middle line.

The relations of the peritoneum to the duodenum, pancreas, and kidneys will be described when these viscera fall to be considered.

Omenta.—The **great** or **gastro-colic omentum (epiploön)** extends from the great curvature of the stomach and first inch of the first part of the duodenum to the transverse colon, descending in its course usually as low as the pelvic brim, and lower on the *left* side than on the right, which accounts for the greater frequency of an omental hernia on the left side. It covers the coils of the jejunum and ileum. At the great curvature of the stomach it contains between its two layers the right and left gastro-epiploic arteries, and the epiploic branches of these vessels, which are long and slender, descend into it. The great omentum is often of small size, thus leaving many of the coils of the small intestine uncovered, or it may even be displaced into the left hypochondrium. It is composed of *four* layers of peritoneum, two of which descend from the great curvature of the stomach, inseparably united, to the region of the pelvic brim, these being called the *anterior* or *descending layers*. The other two layers, also inseparably united, ascend from the region of the pelvic brim to the transverse colon, these being called the *posterior* or *ascending layers*. Between the two anterior and the two posterior layers there is usually, in healthy persons, a space which represents a part of the small cavity of the peritoneum, and is known as the **bag** or **sac of the great omentum.** In many cases, however, this space is scarcely demonstrable on account of adhesions. It is most conspicuous a little below the great curvature of the stomach.

The **small** or **gastro-hepatic omentum** extends from the small curvature of the stomach and first inch of the first part of the duodenum to the portal fissure of the liver, and also to the venosal fissure. It is composed of two layers of peritoneum which, at the small curvature of the stomach, contain between them the anterior and posterior branches of the gastric and pyloric arteries. For the most part its two layers are inseparably united, but at its right border, which is free, it contains between them the following structures: (1) the common bile-duct to the right side; (2) the hepatic artery, invested by the hepatic plexus of sympathetic nerves, to the left side; (3) the vena portæ, which lies between these two, and on a plane posterior to both; and (4) lymphatic vessels. This right or free border, with the foregoing contents, lies in front of the foramen of Winslow. The left border of the gastro-hepatic omentum is short on account of the oblique position of the stomach, and is attached to the diaphragm between the caval and œsophageal openings. The *anterior layer* of the small omentum is formed by peritoneum belonging to the great sac, and the *posterior layer* by that belonging to the small sac, these two layers becoming continuous with each other round the right or free border of the omental fold in front of the foramen of Winslow.

The **gastro-splenic omentum** extends between the posterior surface of the cardiac end of the stomach and the gastric surface of the spleen just in front of the hilum. It is composed of two layers, anterior and posterior, which are continuous with the two anterior layers of the great omentum. The *anterior layer* is formed by peritoneum belonging to the great sac, and the *posterior layer* by that belonging to the small sac. The fold contains between its two layers the vasa brevia of the splenic artery.

Mesenteries.—The **mesentery proper** is the fold of peritoneum which attaches the jejunum and ileum to the vertebral column. Its vertebral border is called the *root*, and is comparatively short, measuring from 5 to 6 inches in length. Its line of attachment extends from the commencement of the jejunum on the *left* side of the body of the second lumbar vertebra, at the anterior border of the pancreas, to the termination of the ileum in the right iliac fossa, near the right sacro-iliac articulation. This line of attachment passes obliquely from left to right, and in this course the root of the mesentery proper crosses in succession the third part of the duodenum, aorta, inferior vena cava, and right psoas magnus. The other border of the mesentery proper is called the *intestinal border*, and is attached to the jejunum and ileum throughout their whole length. This border is of considerable length, and equals that of the jejunum and ileum. The widening of the mesentery proper takes place gradually, so that it is thrown into a number of folds, an arrangement which accounts for the coils of the jejunum and ileum. Its average breadth, from the root to the intestinal border, is about 8 inches. The fold is composed of two layers of peritoneum, right or superior, and left or inferior. The right or superior layer is continuous with the inferior layer of the transverse meso-colon, and with the peritoneum which covers the ascending colon, whilst the left or inferior layer is continuous with the peritoneum which covers the descending colon. Both layers are formed by peritoneum belonging to the **great sac.** The two layers contain between them the following structures: (1) the superior mesenteric vessels, and the rami intestini tenuis; (2) the superior mesenteric plexus of sympathetic nerves, and its secondary offshoots; (3) the lacteal vessels; and (4) the mesenteric lymphatic glands.

In some cases the mesentery proper presents one or more openings, known as mesenteric holes, which may be congenital or traumatic. If a portion of intestine slipped through one of these holes a mesenteric hernia would result, and, if the hole is situated in one layer only, the herniated portion of intestine would take up a position in the space between the two layers. These openings are liable to be met with in that portion of the mesentery proper which is attached to the lower part of the ileum, within the arch formed by the ileo-colic branch of the superior mesenteric artery and the last ramus intestini tenuis (Treves).

The **appendicular mesentery** or **meso-appendix** is a fold of

peritoneum which is derived from the left or inferior layer of the mesentery proper near the terminal part of the ileum. It is triangular, and usually lies obliquely. Its *right end* reaches in a pointed manner to the ileo-cæcal junction, and its *left end* forms a concave free border which transmits the appendicular vessels and sympathetic plexus of nerves. It seldom extends for more than half or two-thirds along the appendix, which is thus rendered more or less convoluted or serpentine. It may, however, extend along its entire length. In some cases it lies vertically, and then it loses its hold upon the mesentery proper, its attachment being transferred to the cæcum, or right fascia iliaca, or even to the back of the ascending colon. The base of the appendix is sometimes destitute of a mesentery, in which cases that portion of it is closely connected to the posterior aspect of the cæcum. Occasionally the entire meso-appendix is awanting, and then the appendix is found adhering to the back of the cæcum. The meso-appendix may present a small opening through which a portion of bowel may pass and become strangulated. In very rare cases the meso-appendix is disposed in such a manner as to divide the ileo-cæcal fossa into an upper and a lower compartment.

The **transverse meso-colon** is a broad fold of peritoneum which extends between the transverse colon and the posterior abdominal wall at the anterior border of the pancreas. Its layers contain between them the middle colic vessels, sympathetic nerves, and the lymphatics of the transverse colon. Mesenteric holes may be present in the transverse meso-colon, under which circumstances a meso-colic hernia may occur.

The **pelvic meso-colon** is a fold of peritoneum which attaches the pelvic colon to the front of the sacrum. It extends from the inner border of the left psoas magnus (covered by the left fascia iliaca) near the left sacro-iliac articulation to the front of the third sacral vertebra, and its length is such as to render the pelvic colon freely movable. Its line of attachment posteriorly extends obliquely from left to right, and it is composed of two layers disposed laterally, and containing between them the superior hemorrhoidal vessels, sympathetic nerves, lymphatic vessels, and a certain amount of fat.

The ascending colon, descending colon, and iliac colon are each, in normal circumstances, devoid of a mesentery. Occasionally, however, an ascending meso-colon, a descending meso-colon, and an iliac meso-colon are present.

Peritoneal Ligaments—Ligaments of the Liver.—The peritoneal ligaments of the liver are four in number (the round ligament not being regarded as of a peritoneal nature), and they are as follows: the falciform ligament, the coronary ligament, the right lateral ligament, and the left lateral ligament.

The **falciform ligament** is also known as the **ligamentum latum** and **suspensory ligament.** It extends between the inferior surface of the diaphragm and the posterior surface of the anterior abdominal

wall on the one hand and the superior and anterior surfaces of the liver on the other. Its base, which is free, extends from the umbilicus to the interlobar notch of the liver, and contains between its two layers the obliterated umbilical vein or round ligament. The line of attachment of the ligament to the anterior and superior surfaces of the liver map the organ out into a right and left lobe, and along this line the two layers of the ligament separate from each other, the right layer extending over the right lobe and the left over the left lobe. Near the postero-superior border of the liver the two layers of the ligament diverge somewhat abruptly, and leave between them a small triangular area which is destitute of peritoneum. Thereafter they become continuous, on either side, with the superior layer of the coronary ligament.

The **coronary ligament** is also known as the **posterior ligament.** It is composed of two layers of peritoneum, superior and inferior, which are attached to the postero-superior and postero-inferior borders of the liver on the one hand, and the diaphragm on the other. These layers are separated from each other by an interval, which corresponds with the uncovered area of the right lobe of the liver. The *superior layer* is continuous with the falciform ligament, and the *inferior layer* is continuous with the peritoneum which covers the inferior vena cava and the front of the right kidney.

The **right** and **left lateral** or **triangular ligaments** are situated at the extreme right and left ends of the coronary ligament, and are formed by the meeting, at these points, of the two layers of that ligament.

The **round ligament** of the liver, though not a peritoneal ligament, may here be described. It is a fibrous cord formed by the obliterated umbilical vein, and is contained within the base of the falciform ligament between the umbilicus and the interlobar notch of the liver, its course between these points being upwards, backwards, and to the right. At the interlobar notch it enters the umbilical fissure on the inferior surface of the liver, and terminates by joining the left branch of the vena portæ.

The ligament of the stomach is called the **gastro-phrenic ligament.** It is of small size, and extends between the region of the uncovered trigone of the stomach and the inferior surface of the diaphragm, lying immediately to the left of the lower end of the œsophagus.

The **ligaments of the spleen** are two in number, namely, phreno-splenic or lieno-phrenic, and lieno-renal.

The **phreno-splenic** or **lieno-phrenic ligament** is also called the **suspensory ligament.** It extends between the spleen, near its upper extremity, and the contiguous part of the diaphragm. The **lieno-renal ligament** extends from the hilum of the spleen to the front of the left kidney at its upper and outer part. Its direction is backwards, and it is composed of two layers of peritoneum, right and left, which contain between them the splenic branches of the splenic artery. The right layer corresponds with the posterior

layer of the gastro-splenic omentum, and the left with the anterior layer of that omentum.

The **phreno-colic** or **costo-colic ligament** (*sustentaculum lienis*) extends between the splenic flexure of the colon and the diaphragm opposite the tenth or eleventh left rib. It is triangular, and its surfaces are superior and inferior, its anterior border being free. It forms a platform upon which the basal surface of the spleen rests.

The **sustentaculum hepatis** is a fold of peritoneum which is sometimes met with in connection with the ascending colon. (Treves found it in eighteen out of one hundred bodies.) When present it extends from the right side of the ascending colon to the abdominal wall at a point a little above the level of the iliac crest. Its free border looks forwards, and it forms a shelf which supports the right margin of the liver.

Cavity of the Peritoneum.—The peritoneal cavity is divided into two compartments, great and small, which communicate with each other through the foramen of Winslow behind the right or free border of the gastro-hepatic omentum.

The **great cavity** or **sac** is the space which is exposed to view after opening the abdominal cavity. It is separated from the small sac by the liver, gastro-hepatic omentum, stomach, gastro-colic omentum, gastro-splenic omentum, lieno-renal ligament, and transverse meso-colon.

The **small cavity** or **sac** is an offshoot from the great sac, the introversion taking place at the foramen of Winslow. It extends upwards behind the stomach to the posterior part of the inferior surface of the diaphragm and the Spigelian lobe of the liver, and downwards into the gastro-colic omentum, the part of it within that omentum being known as the **bag** or **sac of the great omentum.**

Boundaries of the Small Sac—*Anterior.*—From below upwards, the two anterior or descending layers of the gastro-colic omentum, the posterior surface of the stomach, the gastro-hepatic omentum, and the posterior surface of the Spigelian lobe of the liver. *Posterior.*—From below upwards, the two posterior or ascending layers of the gastro-colic omentum, the transverse colon, the transverse meso-colon, and the ascending layer of the transverse meso-colon. *Superior.*—The posterior part of the inferior surface of the diaphragm. *Inferior.*—The bend of the gastro-colic omentum, where the two anterior or descending layers are folded backwards to become the two posterior or ascending layers. *Left.*—The spleen ; the gastro-splenic omentum ; the lieno-renal ligament ; and the left border of the gastro-colic omentum.

In a great many cases that part of the small sac which is contained within the gastro-colic omentum is very limited in its downward extent, on account of adhesions having formed between the layers of the great omentum.

Foramen of Winslow.—This is the opening by which the great and small sacs of the peritoneum communicate with each other. It is situated behind the right or free border of the gastro-hepatic omentum, on a level with the body of the 12th thoracic vertebra.

Its direction is forwards and to the right, and it admits of the passage of one finger, and in some cases of two fingers. It is, however, often blocked by inflammatory products.

Boundaries—*Anterior.*—The right or free border of the gastro-hepatic omentum, containing between its two layers (1) the common bile-duct, to the right side; (2) the hepatic artery, invested by the hepatic plexus of sympathetic nerves, to the left side; (3) the vena portæ, which lies between these two, on a plane posterior to both; and (4) lymphatic vessels. *Posterior.*—The inferior vena cava covered by peritoneum. *Superior.*—The caudate lobe of the liver. *Inferior.*—The first part of the duodenum, and the hepatic artery in the first part of its course, as it curves forwards and upwards from the cœliac axis. When the foramen is blocked by inflammatory products, if fluid should be effused into the small sac the condition known as *hydrops saccatus* would result. It is possible for a loop of bowel to pass through the foramen, thus forming one variety of internal hernia.

Peritoneal Fossæ or Pouches.—The peritoneum presents in certain situations small pockets, which are known as peritoneal fossæ or pouches. Their importance consists in the fact that a small portion of intestine may enter one or other of them and become strangulated, thus constituting an internal hernia, which, except in the cases of the inguinal pouches, is called a retro-peritoneal hernia. The fossæ, according to their situation, are called duodenal, duodeno-jejunal, peri-cæcal, and inter-sigmoid.

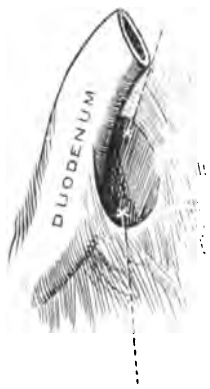


FIG. 299.—DUODENAL FOSSÆ.

Duodenal Fossæ.—Four varieties of duodenal fossæ are met with in connection with the terminal part of the duodenum, namely, inferior duodenal, superior duodenal, para-duodenal, and retro-duodenal (Jonnesco).

The **inferior duodenal fossa** is the most common and largest. It is situated on the left side of the terminal part of the duodenum, and opens *upwards*. It is bounded in front by a thin triangular portion of peritoneum, called the inferior duodenal fold, which presents a free crescentic border or base superiorly. The fossa may admit the thumb, and may be nearly an inch deep. It is said to be present in 75 per cent. of cases (Jonnesco).

The **superior duodenal fossa** is less constant, and of smaller size, than the inferior, and lies about an inch above it. It opens *downwards*, and its orifice faces that of the inferior duodenal fossa. It may admit the tip of a finger. It is bounded in front by a thin triangular portion of peritoneum, called the superior duodenal fold, which presents a free crescentic border or base inferiorly. The fossa is said to be present in 50 per cent. of cases (Jonnesco).

The **para-duodenal fossa** is situated a little to the left of the terminal part of the duodenum. It bounded on the left side by a faint fold of peritoneum, called the inferior mesenteric fold, which is produced by the inferior mesenteric vein.

The **retro-duodenal fossa** is situated behind the terminal part of the duodenum.

Duodeno-jejunal Fossa.—This fossa is situated on the left side of the duodeno-jejunal flexure, and leads upwards and towards the left side. It is

bounded by two free portions of peritoneum, called the duodeno-mesocolic folds, and it has the pancreas above, the left kidney on the left, and the aorta on the right. It is of small size, and may admit the tip of the little finger. It is said to be present in from 15 to 20 per cent. of cases.

Peri-Cæcal Fossæ.—These fossæ are three in number, namely, ileo-colic, ileo-cæcal, and retro-cæcal.

The **ileo-colic fossa** is situated in the angle between the termination of the ileum and the commencement of the ascending colon, in front of the adjacent part of the mesentery proper. It opens *inwards*, and is bounded *in front*

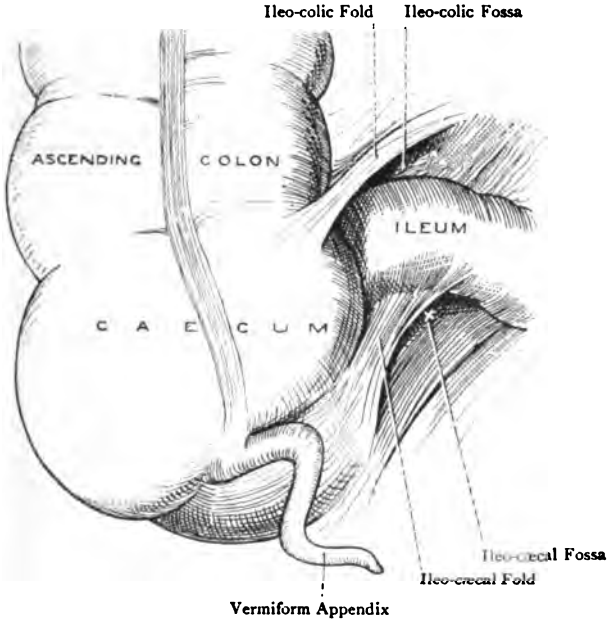


FIG. 300.—ILEO-COLIC AND ILEO-CÆCAL FOSSÆ.

by a portion of peritoneum, called the **ileo-colic fold,** which is produced by the anterior cæcal artery; *behind*, by the mesentery proper; *below*, by the ileum; and, on the *right side*, by the commencement of the ascending colon. In size and depth the fossa is small.

The **ileo-cæcal fossa** is situated in the angle of junction of the ileum and cæcum, and opens downwards and inwards. It may extend upwards for a variable distance behind the ascending colon, and sometimes is capable of admitting two fingers. It is bounded *anteriorly* and *inferiorly* by a portion of peritoneum, called the **ileo-cæcal fold** (bloodless fold of Treves); *posteriorly*, by the meso-appendix; *externally*, by the cæcum; and *superiorly*, by the posterior aspect of the terminal part of the ileum and the inferior layer of the mesentery proper. The importance of this fossa consists in the fact that it often contains the vermiform appendix, or a portion of it.

The **retro-cæcal fossa** is situated behind the cæcum, on the outer side of the meso-appendix. It may extend upwards for a variable distance behind the ascending colon, and is sometimes divided into an external and internal compartment. It occasionally contains the vermiform appendix, or a portion of it.

Intersigmoid Fossa.—This fossa is of rare occurrence in the adult, but is frequently present in early infancy. It is situated on the left side of the pelvic meso-colon near the bifurcation of the left common iliac artery, and is produced by a fold of peritoneum which contains the sigmoid artery. It opens downwards and towards the left side.

The Peritoneum in the Fœtus.—In the fœtus all parts of the abdominal portion of the alimentary canal from the stomach to the rectum are provided with a mesentery. The mesentery of the stomach is called the **mesogastrium,** and is formed by two layers of peritoneum, which extend between the great curvature (at this period looking backwards) and the posterior abdominal wall, where it encloses the pancreas between its two layers. The transverse meso-colon is distinct from the mesogastrium, though in contact with, and

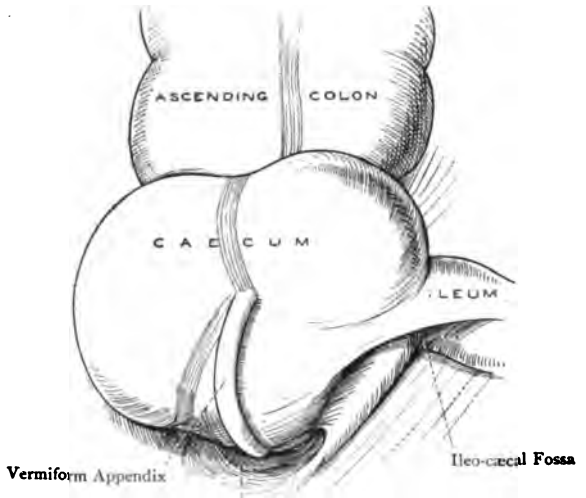


FIG. 301.—THE RETRO-CÆCAL AND ILEO-CÆCAL FOSSÆ.

lying below, it. As the stomach changes its position, the pyloric extremity being tilted forwards and the whole organ turning round upon its right side, the great curvature, which originally looked backwards, is directed downwards and towards the left side. The mesogastrium during this change becomes stretched, and so accommodates itself to the altered position of the organ. Thereafter a gradual extension of the mesogastrium takes place downwards from the great curvature of the stomach over the transverse colon and the jejunum and ileum, and in this manner the great omentum is formed. At first the two posterior or ascending layers of the great omentum pass over the front and upper part of the transverse colon without separating to enclose it, and then backwards to the posterior abdominal wall, lying above the transverse meso-colon. There are thus four layers of peritoneum in this region, the upper two being continuous with the two posterior or ascending layers of the great omentum, and representing the original mesogastrium, and the lower two belonging to the transverse meso-colon. In the latter half of fœtal life the upper two layers become adherent to the upper of the two lower layers of the transverse meso-colon so as to form one layer. The result is that only two layers of peritoneum are now left, instead of the original four. As the result of these changes the pancreas comes to lie *behind* the

peritoneum, whereas it was originally contained between the two layers of the mesogastrium.

The fœtal mesenteries which usually disappear are as follows: the mesogastrium, which is partly developed into the great omentum, and partly incorporated with the upper layer of the transverse meso-colon; the duodenal mesentery; the ascending meso-colon; the descending meso-colon; and the iliac meso-colon.

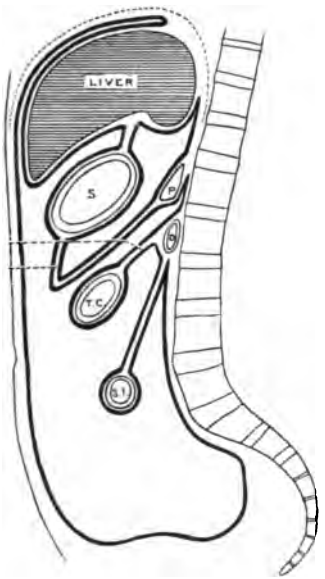


FIG. 302.—DIAGRAM OF THE PERITONEUM IN EARLY LIFE (VERTICAL SECTION).

S. Stomach; P. Pancreas; D. Duodenum; T.C. Transverse Colon; S.I. Small Intestine.

Structure of the Peritoneum.—The peritoneum is a typical serous membrane like the pleura, the serous portion of the pericardium, and the tunica vaginalis. Briefly stated, it consists of a homogeneous connective-tissue basement membrane, containing elastic tissue, and lined with endothelium. Its free surface presents many *stomata* (especially over the diaphragm), which communicate with the cavity of the peritoneum and with the lymph-canalicular system.

Development.—The peritoneum, being a serous membrane, is developed from the walls of the cœlom or body-cavity, which is the cleft in the mesoblast separating the splanchnopleure and somatopleure.

Blood-supply of the Intestinal Canal.—The intestinal canal receives its blood-supply from the superior and inferior mesenteric arteries, with the exception of the upper portion of the duodenum, and a portion of the rectum.

Superior Mesenteric Artery.—This vessel springs from the front of the abdominal aorta about ½ inch below the cœliac axis. It is at first directed downwards behind the neck of the pancreas and the splenic vein. It then passes downwards and forwards in front of the uncinate process of the pancreas and third part of the duodenum, at the lower border of which latter it takes up its position between the two layers of the mesentery proper. The vessel then passes downwards near the root of the mesentery, its course being slightly curved with the convexity towards the left

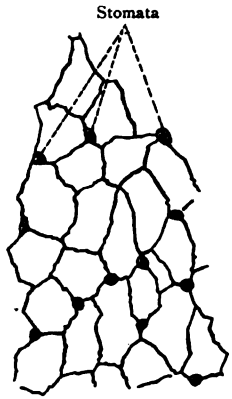


FIG. 303.—ENDOTHELIUM OF A SEROUS MEMBRANE.

side, and it terminates near the ileo-cæcal junction in the last ramus intestini tenuis, which anastomoses with the ileal branch of the ileo-colic artery. The vessel is surrounded by a tough sheath formed by the superior mesenteric sympathetic plexus.

Branches—*Left Branches.*—These are called the **rami intestini tenuis,** and are at least twelve in number. They pass downwards

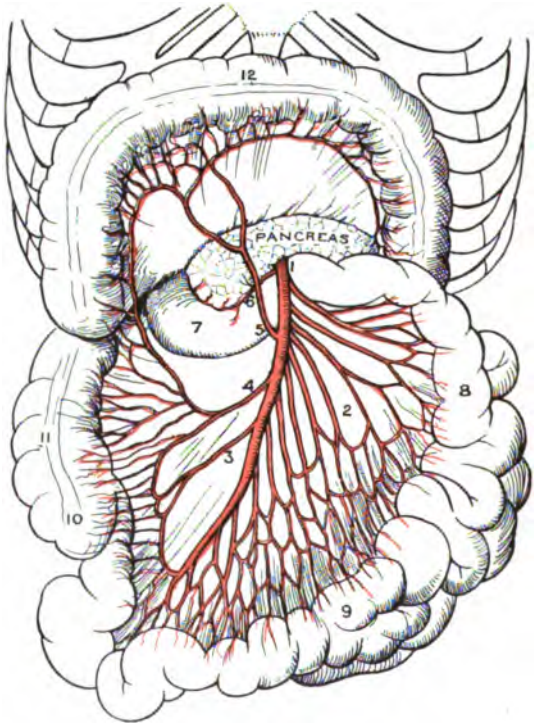


FIG. 304.—THE SUPERIOR MESENTERIC ARTERY AND ITS BRANCHES (AFTER TIEDEMANN).

1. Superior Mesenteric Artery
2. Rami Intestini Tenuis
3. Ileo-colic
4. Right Colic
5. Middle Colic
6. Inferior Pancreatico-duodenal
7. Duodenum
8. Jejunum
9. Ileum
10. Cæcum
11. Ascending Colon
12. Transverse Colon

and to the left *between* the two layers of the mesentery proper, and supply the jejunum and ileum. After a course of about 2 inches each divides into two branches, which by their junction with contiguous branches give rise to primary arches. From the convexities of these arches small branches are given off, which act in a similar manner, and give rise to secondary arches. This disposition of arteries goes on so as to form tertiary, quaternary, and even

quinary arches. The minute vessels arising from the arches of the last tier enter the wall of the jejunum and ileum along the mesenteric border, where each divides into two branches, which encircle the bowel beneath its serous covering. From the rings thus formed branches penetrate deeply to reach the mucous coat. Each ramus intestini tenuis, as well as its various branches, conducts to the bowel an offshoot of the superior mesenteric sympathetic plexus.

Right Branches—**Ileo-colic Artery.**—This vessel is the lowest of the right branches, and in many cases it arises in common with the right colic. Its course is downwards and outwards towards the right iliac fossa *behind* the peritoneum, and it divides into two branches, colic and ileo-cæcal. The *colic branch* passes upwards and forms an arch with the descending branch of the right colic, from which branches proceed to the lower part of the ascending colon. The *ileo-cæcal branch* passes to the upper part of the ileo-cæcal junction, where it furnishes the following branches: *ileal* to the terminal part of the ileum, where it anastomoses with the last ramus intestini tenuis; *appendicular*, which, descending behind the terminal part of the ileum, passes between the two layers of the meso-appendix, and so reaches the vermiform appendix; *anterior cæcal* to the front of the cæcum; and *posterior cæcal* to its posterior aspect.

Right Colic Artery—This is the second branch in order from below upwards, and in many cases it arises in common with the ileo-colic. Its course is transversely to the right *behind* the peritoneum, and it divides into two branches, descending and ascending. The *descending branch* anastomoses with the colic branch of the ileo-colic, and the *ascending branch* with the right branch of the middle colic. The arches thus formed furnish branches to the ascending colon, which in their course form secondary and tertiary arches.

Middle Colic Artery.—This vessel arises from the right side and front of the main trunk about 2 inches above the right colic, on a level with the lower border of the third part of the duodenum. Its course is forwards *between* the two layers of the transverse mesocolon, and it divides into a short right and a long left branch. The *right branch* anastomoses with the ascending branch of the right colic, and the *left branch* with the ascending branch of the left colic from the inferior mesenteric. The arches thus formed furnish branches to the middle colon, which in their course form secondary and tertiary arches.

Inferior Pancreatico-duodenal Artery.—This small vessel usually arises from the right side of the main trunk opposite the upper border of the third part of the duodenum, but it may spring from the first ramus intestini tenuis. Its course is to the right behind the superior mesenteric vein, and between the head of the pancreas and the third part of the duodenum. Thereafter it ascends for a little between the head of the pancreas and the second part of the duodenum, and anastomoses with the superior pancreatico-duodenal of the gastro-duodenal from the hepatic. It supplies the

adjacent portions of the pancreas and duodenum. The vessel is accompanied by an offshoot from the superior mesenteric sympathetic plexus, and, when it arises from the first ramus intestini tenuis, it passes behind the superior mesenteric artery.

Superior Mesenteric Vein.—This vein is formed by tributaries which return the blood from the parts of the intestinal canal supplied by the superior mesenteric artery, and it receives in addition the right gastro-epiploic vein. It ascends on the right side of the superior mesenteric artery. After leaving the mesentery it passes over the third part of the duodenum and uncinate process of the pancreas, and finally behind the neck of the latter organ, where it joins the splenic vein to form the vena portæ. The vessel and its tributaries are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Superior Mesenteric Sympathetic Plexus.—This plexus is derived from the solar plexus. It closely surrounds the superior mesenteric

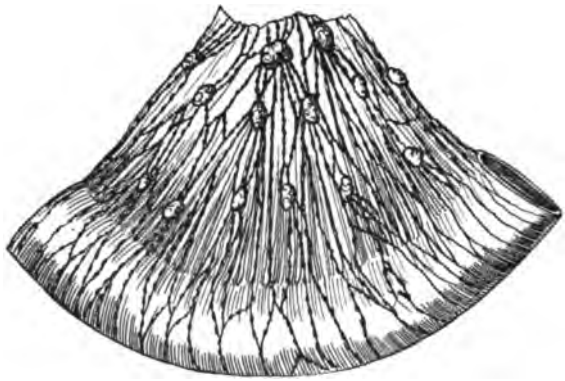


FIG. 305.—PORTION OF JEJUNUM WITH ITS MESENTERY, SHOWING LACTEAL VESSELS AND MESENTERIC GLANDS.

artery in the form of a tough sheath, and it furnishes offshoots which accompany all the branches of that vessel.

Lymphatic Vessels of Small Intestine.—These, which are called **lacteals,** originate in the villi of the mucous membrane of the small intestine (see p. 742). They leave the wall of the bowel at the mesenteric border, those of the jejunum exceeding in number those of the ileum. Within the mesentery they take a course inwards and upwards, becoming, in succession, the afferent and efferent vessels of the groups of mesenteric glands. At the root of the superior mesenteric artery the lacteals, which have now emerged from the innermost mesenteric glands, terminate in from one to four lymphatic trunks, which open into the **receptaculum chyli.**

Mesenteric Glands.—These are about 150 in number, and are situated within the arterial arches, and along the course of the trunk,

of the superior mesenteric artery. In health their average size is about that of a small pea, except along the course of the main artery, where they are somewhat larger, and they are more numerous in the jejunal than in the ileal mesentery. They receive the lacteals from the lower part of the duodenum, the jejunum, and the ileum,

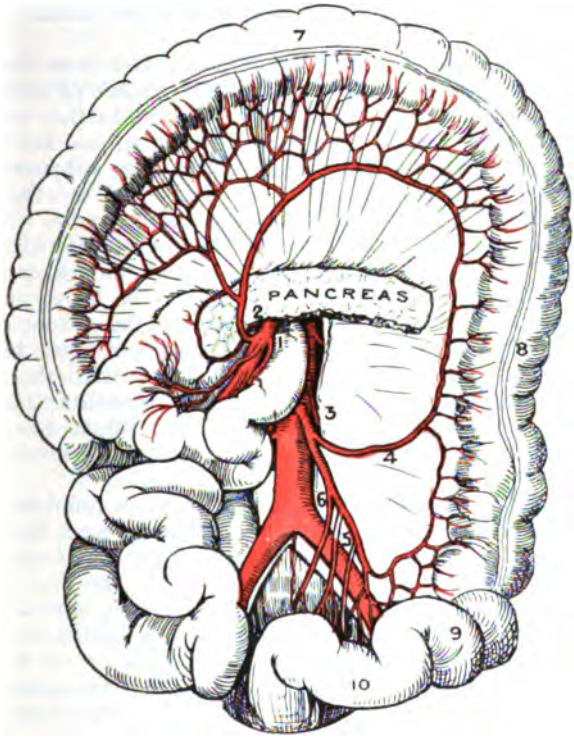


FIG. 306.—THE INFERIOR MESENTERIC ARTERY AND ITS BRANCHES (AFTER TIEDEMANN).

1. Superior Mesenteric Artery
2. Middle Colic
3. Inferior Mesenteric
4. Left Colic
5. Arteriæ Sigmoideæ
6. Superior Hemorrhoidal
7. Transverse Colon
8. Descending Colon
9. Iliac Colon
10. Pelvic Colon

and also the lymphatics from the lower part of the ascending colon. There are no glands in the portion of mesentery close to the intestine for about 2 inches. In the ileo-colic angle there is a special group of glands, called the **ileo-colic glands.** These receive affe ent vessels from the terminal part of the ileum, the cæcum, and the vermiform appendix, and their efferent vessels pass to the innermost group of mesenteric glands.

Lymphatic Vessels of Ascending and Transverse Colon.—The lymphatics of the ascending colon terminate in two ways, as follows: those from the lower part pass to the innermost group of mesenteric glands, whilst those from the upper part go to the meso-colic glands. The lymphatics of the transverse colon become afferent vessels of the meso-colic glands, the efferent vessels of which join the terminal intestinal lymphatic trunks from the mesenteric glands.

Inferior Mesenteric Artery.—This vessel arises from the front of the abdominal aorta towards its left side, about 1½ inches above the bifurcation. Its course is downwards and to the left towards the left iliac fossa. It is *behind* the peritoneum, and lies first upon the aorta, and then on its left side, where it is supported by the psoas magnus. Subsequently it is continued as the superior hemorrhoidal artery over the left common iliac vessels. The artery is surrounded by the inferior mesenteric sympathetic plexus.

Branches—Left Colic Artery.—This vessel passes transversely to the left, *behind* the peritoneum and over the lower part of the left kidney, and it divides into two branches, ascending and descending. The *ascending branch* anastomoses with the left branch of the middle colic, and the *descending branch* with the ascending branch of the superior sigmoid artery. The arches thus formed supply branches to the left extremity of the transverse colon and the descending colon, which in their course form secondary and tertiary arches.

Sigmoid Arteries.—These are usually three in number, superior, middle, and inferior, but they frequently arise as a single trunk. They pass downwards and to the left over the psoas magnus, and supply the lower part of the descending colon, the iliac colon, and the pelvic colon. The *superior sigmoid artery*, which lies, as a rule, *behind* the peritoneum, divides into two branches, ascending and descending. The ascending branch forms an arch with the descending branch of the left colic, and the descending branch passes between the two layers of the pelvic meso-colon, where it anastomoses with the middle sigmoid artery. The *middle* and *inferior sigmoid arteries* pass between the two layers of the pelvic meso-colon, where they form arches with the descending branch of the superior sigmoid, with one another, and with the superior hemorrhoidal artery. The branches of these arches form secondary, or even tertiary, arches before the terminal branches are given off.

The **superior hemorrhoidal artery** is the continuation of the inferior mesenteric, and will be found described on p. 820.

Inferior Mesenteric Vein.—This vein is formed by tributaries which return the blood from the parts of the large intestine supplied by the inferior mesenteric artery. It lies at first near the left side of its artery, but soon leaves it and ascends on the left psoas magnus, where it lies on the left side of the aorta behind the peritoneum. In this course it crosses the left spermatic artery and left renal vein. It finally passes behind the pancreas with an

inclination to the right, and usually terminates in the splenic vein. It may, however, open into the angle of junction of the splenic and superior mesenteric veins, or into the superior mesenteric vein, near its termination. The inferior mesenteric vein and its tributaries are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Inferior Mesenteric Sympathetic Plexus.—This plexus is derived from the left half of the aortic plexus. It forms a tough sheath round the artery, and furnishes offshoots with its branches.

Lymphatic Vessels of Descending, Iliac, and Pelvic Colon.—The lymphatics of the descending colon terminate in two ways, as follows: those of the upper part pass to the meso-colic glands, whilst those of the lower part join the left lymphatic trunk from the median lumbar glands. The lymphatics of the iliac and pelvic colon also join the left lymphatic trunk from the median lumbar glands.

Lymphatic Glands of Large Intestine (colic glands). — These glands are arranged in groups, named according to the portion of intestine to which they are related, and they are situated behind the respective parts, except those belonging to the transverse colon which lie between the two layers of the transverse meso-colon, and are known as the **meso-colic glands.**

Position and Connections of the Duodenum.—The duodenum is the first part of the small intestine. It measures from 10 to 11 inches in length, and is the widest and least movable part. It extends from the pylorus to the left side of the body of the *second* lumbar vertebra, where it ends in the jejunum. It describes a somewhat **U**-shaped curve with the concavity directed upwards and to the left in close adaptation to the head of the pancreas. It is devoid of a mesentery, and is divided into three parts, first, second, and third.

First or **Superior Part.**—The first part extends from the pylorus to the right side of the neck of the gall-bladder. It lies in the epigastric region, and is about 2 inches in length, its direction being upwards, backwards, and to the right when the stomach is empty, but directly backwards when that organ is distended. The gastro-hepatic omentum furnishes a complete covering to about the first inch, and the remainder is covered by peritoneum only in front. The first part is therefore comparatively movable.

Relations—*Superior* and *Anterior.*—The quadrate lobe of the liver and the gall-bladder. *Posterior.*—The vena portæ, gastro-duodenal artery, common bile-duct, and neck of the pancreas. *Inferior.*—The head of the pancreas. The first part lies below the foramen of Winslow.

Second or **Descending Part.**—This part extends from the right side of the neck of the gall-bladder to the right side of the body of the third (sometimes fourth) lumbar vertebra. It lies at first in the epigastric, and subsequently in the umbilical, region; its length is from 3 to 4 inches, and its direction is almost vertically downwards behind the right extremity of the transverse colon. The anterior surface is

covered by peritoneum, except opposite the transverse colon. If there is no transverse meso-colon at this point, there is a distinct strip near the centre left uncovered and connected to the colon by areolar tissue. If, however, there is a transverse meso-colon present at this point, the bare area is trifling. The posterior surface is destitute of peritoneum. The second part is therefore very immovable.

Relations—*Anterior.*—From above downwards the gall-bladder near its neck, the right extremity of the transverse colon, and some coils of the small intestine. *Posterior.*—The anterior surface of the right kidney near the hilum, and the inferior vena cava. *Right.*—The hepatic flexure of the colon, and the right lobe of the liver. *Left.*—The head of the pancreas, with the common bile-duct behind, and the superior pancreatico-duodenal artery in front. The common bile-duct and pancreatic duct enter the wall of this part at the junction of the inner and posterior aspects, a little below the centre.

Third or **Inferior Part.**—This part extends from the right side of the body of the third (sometimes fourth) lumbar vertebra to the left side of the body of the second on a level with its upper border. At this point it makes a sharp bend forwards, and terminates in the jejunum, thus forming the *duodeno-jejunal flexure.* It lies at first in the umbilical, and subsequently in the epigastric, region; its length is about 5 inches, and its direction is at first obliquely to the left and upwards, and afterwards vertically upwards. Its anterior surface is covered by peritoneum derived from the descending layer of the transverse meso-colon, except where it has the superior mesenteric vessels in front of it. There is no peritoneum behind it, and consequently it is fixed in position.

Relations—*Anterior.*—The superior mesenteric vessels and the upper part of the root of the mesentery, with portions of the small intestine on either side of these. *Posterior.*—The inferior vena cava, aorta (below the origin of the superior mesenteric artery), left renal vein, left psoas magnus, and left crus of the diaphragm. *Superior.*—The lower part of the head of the pancreas (including its uncinate process), and the inferior pancreatico-duodenal artery.

The terminal portion of the third part is sometimes spoken of as the *fourth* or *ascending part of Treves.* It is covered by peritoneum on the left side, as well as in front, and in cases where a retro-duodenal fossa is present it is partially covered by peritoneum behind, towards the left side. The duodenal fossæ of the peritoneum are met with on the left side of this portion. The duodeno-jejunal flexure is suspended from the left crus of the diaphragm by a fibro-muscular bundle, called the *musculus suspensorius duodeni.*

Position and Connections of the Pancreas.—The pancreas is a long narrow gland which is situated behind the stomach, on a level with the first and second lumbar vertebræ. Its right extremity occupies the duodenal curve, and its somewhat pointed left ex-

tremity is in contact with the spleen. The greater part of the organ lies in the epigastric region, but its left extremity is situated in the left hypochondrium. The antero-superior surface is covered by the ascending layer of the transverse meso-colon, and the inferior surface by the descending layer, but the posterior surface is destitute of serous covering. The length of the organ is from 6 to 8 inches, its depth from 1 to 1½ inches, except at the right and left extremities, and its thickness from ½ to ¾ inch. Its weight is about 3½ ounces.

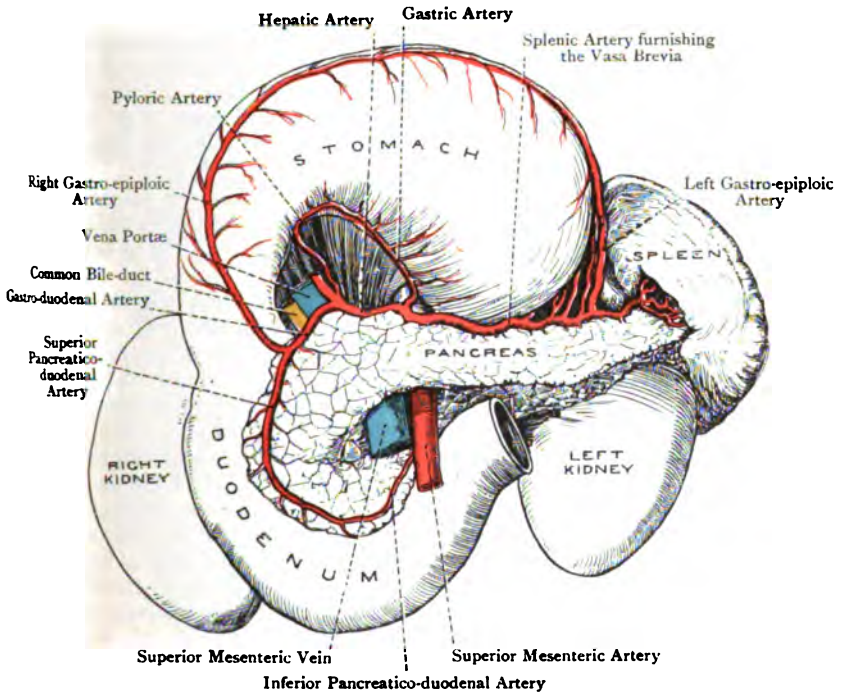


FIG. 307.—THE ARTERIES OF THE STOMACH, DUODENUM, PANCREAS, AND SPLEEN.

It has been likened in shape to the capital letter J laid thus ⊏ (Birmingham). For convenience of description it is divided into a head, neck, body, and tail.

The **head** is the enlarged flattened right extremity. It chiefly corresponds with, and is closely attached to, the second and third parts of the duodenum as far almost as the duodeno-jejunal flexure. The expansion of the head to the left along the upper part of the third portion of the duodenum is called the *uncinate process*.

Relations—*Anterior*.—The transverse colon with its meso-colon, and the superior mesenteric vessels crossing the uncinate process.

Posterior.—The inferior vena cava, right crus of the diaphragm, aorta, and left renal vein. *Superior.*—The first part of the duodenum. *Inferior.*—The third part of the duodenum, and the inferior pancreatico-duodenal artery. *Right.*—The second part of the duodenum, with the common bile-duct behind, as low as a little below the centre, and the superior pancreatico-duodenal artery in front.

The **neck** (Symington) may be defined as the part in front of the origin of the vena portæ and the termination of the superior mesenteric vein. It springs from the anterior surface of the head near its upper part, and is about 1 inch in length. Its direction is upwards and to the left, and it forms the connecting link between the head and body. The gastro-duodenal and superior pancreatico-duodenal arteries occupy a groove on its right side, and the commencement of the first part of the duodenum is in front of it, whilst the origin of the vena portæ and the termination of the superior mesenteric vein are behind it.

The **body** passes to the left, with a slight inclination backwards after it has crossed the aorta. It is triangular, and presents three surfaces—antero-superior, posterior, and inferior, and three borders —superior, anterior, and posterior.

The *antero-superior surface*, which is covered by peritoneum, is in relation with the posterior surface of the stomach. At its right extremity, just below the cœliac axis, it presents a prominence, called the **omental tuberosity** from its relation to the gastro-hepatic omentum. The *posterior surface*, which is destitute of peritoneum, is related to the following structures: the aorta below the cœliac axis, with a portion of the solar plexus; the origin of the superior mesenteric artery; the left suprarenal capsule; and the left kidney with its vessels. The splenic vein passes from left to right in contact with this surface near the superior border. The *inferior surface*, which is covered by peritoneum, is moulded on the duodeno-jejunal flexure, some coils of the jejunum, and the left extremity of the transverse colon. The cœliac axis projects forwards over the *superior border* above the omental tuberosity. To the left of this axis the splenic artery pursues its tortuous course to the spleen, and to the right of it the hepatic artery lies for a short distance. The transverse mesocolon is attached to the *anterior border* along which its separation into ascending and descending layers takes place, the former covering the antero-superior surface of the organ, and the latter, on its way backwards, investing the inferior surface. The *posterior border* presents nothing noteworthy.

The **tail** corresponds with the left extremity where the pancreas is narrowest, and is in contact with the lower end of the gastric surface of the spleen behind the hilum.

For the structure and development of the pancreas, see pp. 759, 762.

Solar or Epigastric Plexus of the Sympathetic System.—The solar plexus is of large size, and is situated deeply in the epigastric region, behind the stomach and in front of the crura of the diaphragm and the aorta close to the origins of the cœliac axis and

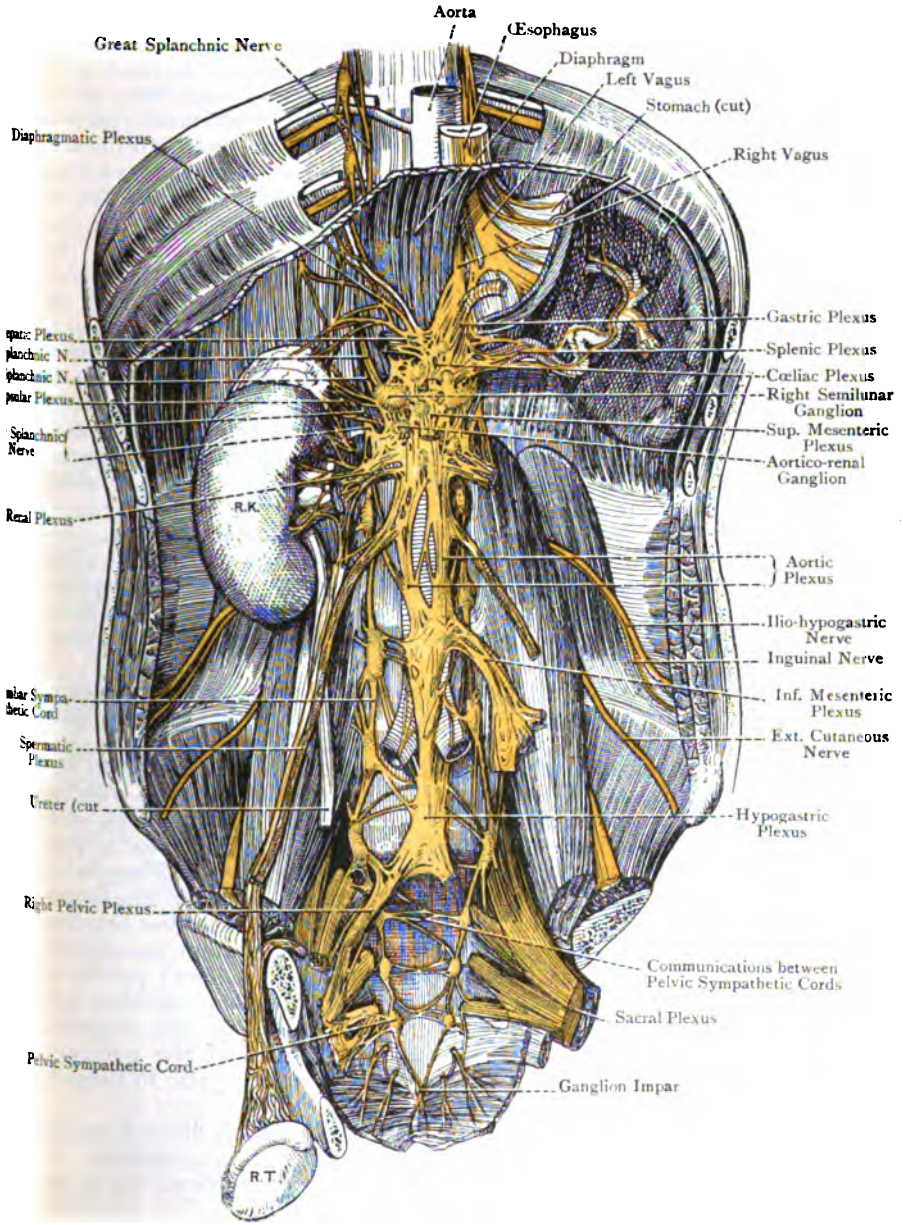


FIG. 308.—THE SYMPATHETIC SYSTEM IN THE ABDOMEN AND PELVIS (HIRSCHFELD AND LEVEILLÉ).

R.K. Right Kidney; R.T. Right Testis.

superior mesenteric artery. It extends from one suprarenal capsule to the other, and is composed of nerve-fibres and ganglia, with an admixture of adipose tissue. The plexus receives its chief fibres from the great and small splanchnic nerves of each side, which contain a large number of spinal fibres. The great splanchnic nerve is formed by roots derived usually from the fifth to the ninth thoracic sympathetic ganglia inclusive, and it enters the abdomen by piercing the crus of the diaphragm. The small splanchnic nerve arises by two roots from the tenth and eleventh thoracic ganglia, and it also enters the abdomen by piercing the crus of the diaphragm. The plexus also receives fibres from the right pneumogastric nerve. Two of the ganglia of the solar plexus are of large size, and are situated one at either lateral pole. They are called the *semilunar ganglia*, right and left. Each lies over the corresponding crus of the diaphragm close to the suprarenal body, that of the right side being under cover of the inferior vena cava, and each receives at its upper part the great splanchnic nerve. The lower part of each ganglion is more or less detached, and is known as the *aortico-renal ganglion*, which lies over the root of the renal artery, and in which the small splanchnic nerve terminates. From each semilunar ganglion branches proceed in a radiating manner upwards, outwards, downwards, and inwards. The inner group of fibres extend from one ganglion to the other, embracing the cœliac axis as they cross the aorta, and forming the cœliac plexus, which receives fibres from the right pneumogastric nerve, and contains numerous small ganglia.

The **cœliac plexus** furnishes three secondary plexuses—gastric, splenic, and hepatic. The *gastric plexus* accompanies the corresponding artery to the small curvature of the stomach, and supplies branches to the adjacent portions of the anterior and posterior surfaces of that organ. The *splenic plexus* goes with the splenic artery, and receives branches from the right pneumogastric nerve. It is distributed, with the branches of the artery, to the pancreas, cardiac extremity of the stomach, left half of its great curvature and adjacent portions of its surfaces, and the spleen. The *hepatic plexus* accompanies the artery of that name, and receives branches from the left pneumogastric nerve. Its distribution corresponds with that of the artery, and its offshoots are as follows: pyloric to the small curvature of the stomach; gastro-duodenal, dividing into right gastro-epiploic to the great curvature of the stomach, and superior pancreatico-duodenal to the head of the pancreas, and the first and second parts of the duodenum; cystic to the gall-bladder; and hepatic to the liver.

The **diaphragmatic** or **phrenic plexus** receives its fibres from the upper part of the semilunar ganglion, and it accompanies the inferior phrenic artery to the diaphragm, giving branches in its course to the suprarenal plexus.

The **suprarenal plexus** receives its fibres from the semilunar ganglion and cœliac plexus. It contains small ganglia, and is

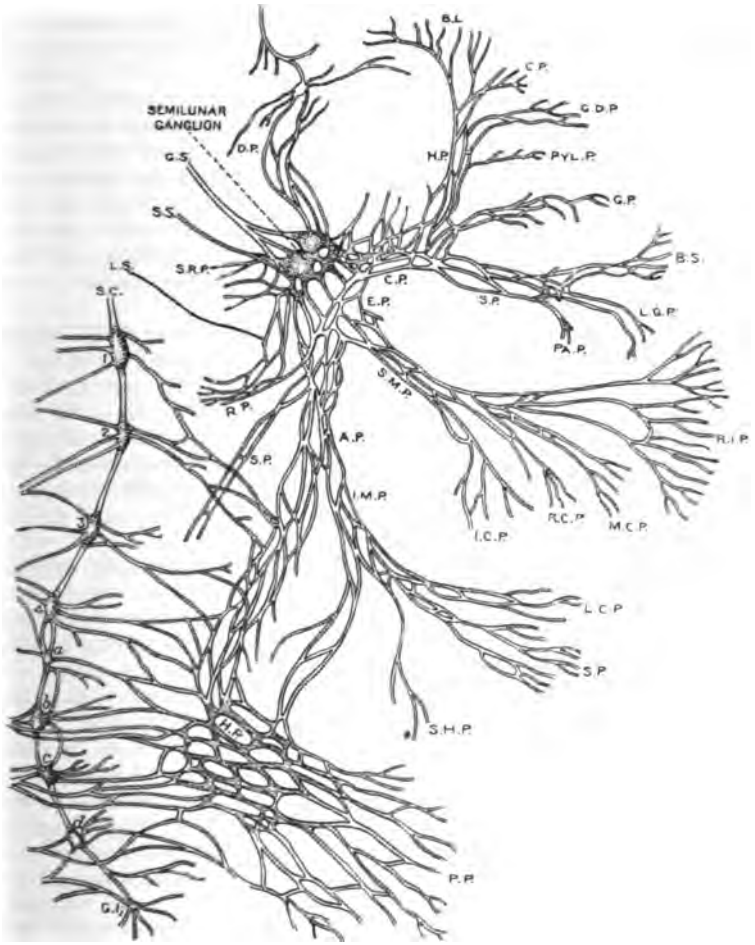


FIG. 309.—SCHEME OF THE SYMPATHETIC NERVE IN THE ABDOMEN AND PELVIS (FLOWER).

S.C. Sympathetic Cord
1,2,3,4. Lumbar Ganglia
a,b,c,d. Pelvic Ganglia
G.I. Ganglion Impar
G.S. Great Splanchnic
S.S. Small Splanchnic
L.S. Least Splanchnic
D.P. Diaphragmatic Plexus
S.R.P. Suprarenal Plexus
R.P. Renal Plexus
S.P. Spermatic Plexus
A.P. Aortic Plexus
I.M.P. Inferior Mesenteric Plexus
L.C.P. Left Colic Plexus
S.P. Sigmoid Plexus
S.H.P. Superior Hemorrhoidal Plexus
H.P. Hypogastric Plexus
P.P. Pelvic Plexus
E.P. Epigastric Plexus
C.P. Cœliac Plexus
S.P. Splenic Plexus
Pa.P. Pancreatic Plexus
L.G.P. Left Gastro-epiploic Plexus
B.S. Branches to Spleen
G.P. Gastric Plexus
H.P. Hepatic Plexus
Pyl.P. Pyloric Plexus
G.D.P. Gastro-duodenal Plexus
C.P. Cystic Plexus
B.L. Branches to Liver
S.M.P. Superior Mesenteric Plexus
I.C.P. Ileo-colic Plexus
R.C.P. Right Colic Plexus
M.C.P. Middle Colic Plexus
R.I.P. Rami Intestini Tenuis Plexuses

joined from above by branches from the diaphragmatic plexus, and below by branches from the renal plexus. It is distributed to the suprarenal capsule.

The **renal plexus** derives its fibres from the aortico-renal ganglion, the cœliac and aortic plexuses, and the least splanchnic nerve when present. (The least splanchnic nerve arises from the twelfth thoracic ganglion, and enters the abdomen behind the ligamentum arcuatum internum, or through the crus of the diaphragm). The fibres of the renal plexus, which contain ganglia here and there, are distributed with the renal artery to the kidney, branches being also given to the suprarenal plexus, spermatic plexus (ovarian in the female), and to the ureter.

The **superior mesenteric plexus** is a continuation of the cœliac plexus, and also receives fibres from the semilunar ganglia. It contains a ganglion, called *superior mesenteric*, in contact with the origin of the artery of that name, and it accompanies that vessel and its branches to be distributed to the intestinal canal from (and including) the third part of the duodenum to the commencement of the descending colon. Its secondary plexuses are as follows: rami intestini tenuis, ileo-colic, right colic, middle colic, and inferior pancreatico-duodenal.

The **aortic plexus** derives its fibres from the semilunar ganglia, and the cœliac and superior mesenteric plexuses. It extends along the aorta, beyond the origin of the superior mesenteric artery, in the form of two lateral strands which communicate freely with one another over the vessel by many interlacing fibres. It is reinforced laterally by branches from the lumbar portion of the gangliated sympathetic cord. The two lateral strands of the plexus ultimately cross the common iliac arteries, and unite in front of the body of the fifth lumbar vertebra to form the hypogastric plexus. The aortic plexus furnishes, on either side, branches to the renal and spermatic (or ovarian) plexuses, and supplies the coats of the aorta. The right strand gives branches to the inferior vena cava, and the left furnishes the chief fibres of the inferior mesenteric plexus.

The **spermatic plexus** derives its fibres from the renal and aortic plexuses, and accompanies the spermatic artery to the testis. In the female it is called the **ovarian plexus,** which goes with the artery of that name to the ovary.

The **inferior mesenteric plexus** is derived chiefly from the left strand of the aortic plexus, and contains a ganglion, called *inferior mesenteric*, which lies below the root of the inferior mesenteric artery. The plexus accompanies the inferior mesenteric artery, and furnishes left colic, sigmoid, and superior hemorrhoidal plexuses, which supply the descending colon, iliac colon, pelvic colon, and rectum.

The **hypogastric plexus** is formed by the fusion of the two halves of the aortic plexus after these have crossed the common iliac arteries. It is reinforced by branches from the lumbar ganglia, and is

situated in front of the body of the fifth lumbar vertebra between the common iliac vessels. It is a large flat plexus, measuring about 1½ inches in breadth, and it ends in two divisions, which become the right and left pelvic plexuses.

Cœliac Axis.—The cœliac axis is a short thick trunk which arises from the front of the aorta between the crura of the diaphragm just below the aortic opening. Its direction is straight forwards over the superior border of the body of the pancreas, and, after a course of about ½ inch, it divides into three radiating branches—gastric, splenic, and hepatic. Of these the splenic is the largest, except during fœtal life when it is exceeded by the hepatic. The branches of the axis supply the stomach, duodenum, pancreas, spleen, liver, and gall-bladder.

Relations.—The right lobe of the liver *above*, the superior border of the body of the pancreas *below*, the gastro-hepatic omentum *in front*, and a semilunar ganglion *on either side*, with the Spigelian lobe of the liver as an additional *right* relation. The axis is closely surrounded by the cœliac sympathetic plexus.

The **gastric** (coronary) **artery** is directed upwards and to the left as far as the small curvature of the stomach on the right side of the œsophagus. It then bends sharply forwards and downwards, and descends in two divisions from left to right along the small curvature towards the pylorus, where it anastomoses with the two divisions of the pyloric branch of the hepatic. The artery is at first behind the small sac of the peritoneum, but along the small curvature it lies between the two layers of the gastro-hepatic omentum, and is surrounded by the gastric sympathetic plexus.

Branches.—These are œsophageal, cardiac, and gastric. The *œsophageal branches* arise when the artery reaches the small curvature, and they ascend through the œsophageal opening of the diaphragm to anastomose on the gullet with the lower œsophageal branches of the thoracic aorta. The *cardiac branches* are distributed to the cardiac end of the stomach, where they anastomose with the vasa brevia of the splenic. The *gastric branches* arise from the two divisions of the artery on the small curvature, and pass to the front and back of the stomach, where they anastomose with branches of the gastro-epiploic arteries.

The **gastric vein** ascends from right to left along the small curvature of the stomach as far as the œsophagus, where it receives a few œsophageal tributaries, after which it turns to the right and opens into the vena portæ.

The **splenic artery** takes a tortuous course to the left along the superior border of the body of the pancreas behind the small sac. On reaching the front of the left kidney it breaks up into several splenic branches which enter the spleen through the hilum. The artery is invested by the splenic sympathetic plexus, and the splenic vein lies below it, and behind the pancreas.

Branches.—These are pancreatic, left gastro-epiploic, vasa brevia,

and splenic. The *pancreatic branches* arise at intervals along the superior border of the pancreas, which they enter. One of them, known as the *arteria pancreatica magna*, enters the organ towards its left end, and passes from left to right, lying a little above the pancreatic duct. The *left gastro-epiploic artery* arises near the spleen, and passes within the gastro-splenic omentum to the great curvature of the stomach, along which it descends from left to right

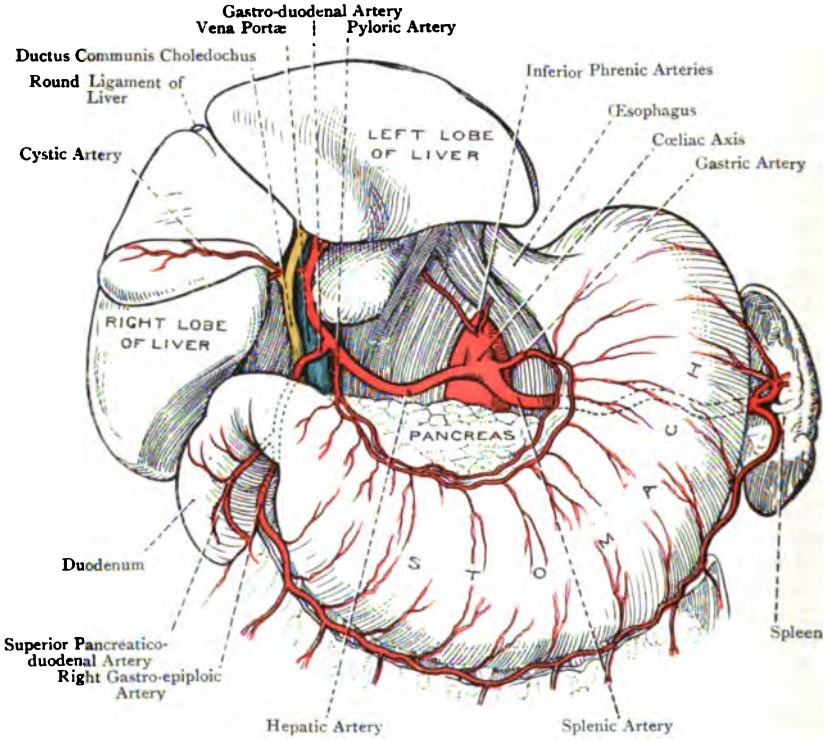


FIG. 310.—THE ARTERIES OF THE STOMACH, LIVER, AND SPLEEN (AFTER MERKEL).

between the two layers of the gastro-colic omentum as far as the centre, where it anastomoses with the right gastro-epiploic. It furnishes *gastric branches* to the front and back of the stomach, which anastomose with branches of the gastric artery, and *epiploic branches*, which descend into the gastro-colic omentum, these latter being long and slender. The *vasa brevia* arise from the terminal part of the splenic and from its splenic branches. They are about five in number, and, having passed within the gastro-splenic omentum to the cardiac extremity of the stomach, they

anastomose with branches of the left gastro-epiploic and gastric arteries. The *splenic branches* are about five in number, and pass to the spleen within the lieno-renal ligament.

The **splenic vein** is formed by the union of about five veins which emerge from the spleen. It is of large size, and passes from left to right behind the pancreas near its superior border, where it lies below the splenic artery. Having crossed the aorta, it joins the superior mesenteric vein to form the vena portæ behind the neck of the pancreas. The vein takes up the following tributaries: the vasa brevia, the left gastro-epiploic, many pancreatic veins, and the inferior mesenteric (as a rule).

The **hepatic artery** passes at first to the right along the superior border of the pancreas for a short distance, where it lies behind the small sac. It then turns forwards *below* the foramen of Winslow to the upper border of the first part of the duodenum near the pylorus, and it subsequently ascends between the two layers of the gastro-hepatic omentum *in front of* the foramen of Winslow towards the portal fissure of the liver, on approaching which it divides into a right and left hepatic branch. The vessel is accompanied by the hepatic sympathetic plexus. As it ascends between the two layers of the gastro-hepatic omentum it has the common bile-duct on its right side, the vena portæ being behind both.

Branches.—These are pyloric, gastro-duodenal, and right and left hepatic. The *pyloric artery*, of small size, arises near the pylorus, and passes to the small curvature of the stomach, where it divides into two branches. These lie between the two layers of the gastro-hepatic omentum, and supply offsets to the front and back of the stomach, which anastomose with the two divisions of the gastric artery. The *gastro-duodenal artery* also arises near the pylorus, and descends behind the first part of the duodenum, having the common bile-duct on its right, and the vena portæ behind it. Having reached the lower border of the first part of the duodenum, it occupies a groove on the right of the neck of the pancreas, and here divides into its two terminal branches—right gastro-epiploic and superior pancreatico-duodenal. The *right gastro-epiploic artery* passes from right to left along the great curvature of the stomach as far as its centre between the two layers of the gastro-colic omentum, and its distribution and anastomoses are similar to those of the left gastro-epiploic artery. The *superior pancreatico-duodenal artery* descends anteriorly between the head of the pancreas and the second part of the duodenum, towards the lower end of which latter it anastomoses with the inferior pancreatico-duodenal of the superior mesenteric. It supplies the first and second parts of the duodenum, and furnishes branches to the adjacent portion of the pancreas. The *hepatic branches* are the terminal divisions of the trunk. The *right*, which is the larger, enters the portal fissure at its right end, whilst the *left*, small in size, enters that fissure at its left end, having previously furnished a branch to

the Spigelian lobe. The right branch gives off the *cystic artery*, and this divides into two branches, superior and inferior, which ramify on the upper and under surfaces of the gall-bladder.

The *pyloric vein* passes from left to right, and opens into the vena portæ near the pylorus.

The *right gastro-epiploic vein* passes from left to right, and opens into the superior mesenteric vein near its termination.

The *pancreatico-duodenal vein* takes up blood from the right end of the pancreas and from the duodenum, and opens into the superior mesenteric vein near its termination.

The *cystic vein* usually ends in the right division of the vena portæ.

All the veins which return the blood from the stomach, duodenum, pancreas, and spleen are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Cœliac Glands.—The glands of this group are numerous. They surround the cœliac axis, and extend over the aorta as low as the origin of the superior mesenteric artery. They receive their afferent vessels from the gastric, pancreatic, splenic, and hepatic glands, and their efferent vessels either join the intestinal lymphatic trunk (or trunks) of the mesenteric glands, or open independently into the receptaculum chyli.

Gastric Glands.—These are arranged in two groups, superior and inferior, the former lying along the small curvature of the stomach, and the latter along the great curvature. They receive their afferent vessels from the stomach, and their efferent vessels pass to the cœliac glands.

Pancreatic Glands.—These lie along the superior border of the pancreas. They receive their afferent vessels from that organ, and their efferent vessels pass to the cœliac glands.

Splenic Glands.—These are numerous, and are situated near the hilum of the spleen in contact with the tail of the pancreas. They receive their afferent vessels from the spleen, and their efferent vessels, having been joined by some of those from the left half of the great curvature of the stomach, pass to the cœliac glands.

Hepatic Glands.—These are situated between the two layers of the gastro-hepatic omentum near the portal fissure. They receive as afferent vessels those of the deep lymphatics of the liver which accompany the branches of the portal vein, and also some of the superficial lymphatics of the inferior surface of the liver, and their efferent vessels pass to the cœliac glands.

Vena Portæ.—This vein is formed by the union of the superior mesenteric and splenic veins, and is about 3 inches in length. It commences on a level with the body of the *first* lumbar vertebra a little to the right of the middle line, where it lies behind the neck of the pancreas and in front of a portion of the head. It ascends behind the first part of the duodenum, and then between the two layers of the gastro-hepatic omentum in front of the foramen of Winslow, where it has anterior to it the hepatic artery and common bile-duct,

the artery being on the left of the duct. When the vessel arrives at the right extremity of the portal fissure of the liver it presents a slight enlargement, called the *portal sinus*, and then divides into two branches, right and left, the former being the larger and shorter of the two. The *right branch*, having received the cystic vein, enters the right lobe of the liver. The *left branch*, having traversed the portal fissure from right to left, and furnished branches to the quadrate and Spigelian lobes, crosses the longitudinal fissure, and

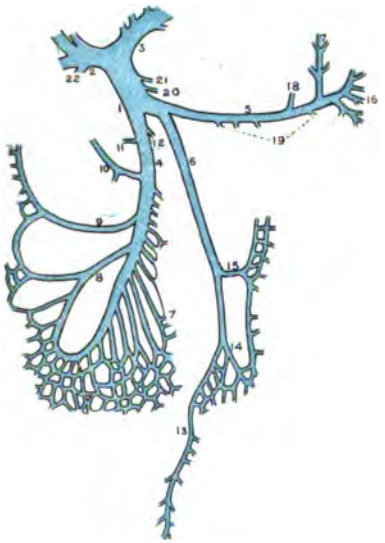


FIG. 311.—VENA PORTÆ AND ITS TRIBUTARIES.

1. Vena Portæ
2. Right Division
3. Left Division
4. Superior Mesenteric
5. Splenic
6. Inferior Mesenteric
7. Rami Intestini Tenuis
8. Ileo-Colic
9. Right Colic
10. Middle Colic
11. Right Gastro-epiploic
12. Pancreatico-duodenal
13. Superior Hemorrhoidal
14. Sigmoid
15. Left Colic
16. Splenic Veins
17. Vasa Brevia
18. Left Gastro-epiploic
19. Pancreatic
20. Pyloric
21. Gastric
22. Cystic

enters the left lobe. As it crosses this fissure it is joined in front by the round ligament of the liver, which is the remains of the umbilical vein of fœtal life. Posteriorly, and slightly to the right of this point, it is connected with the fibrous cord which represents the fœtal ductus venosus. The vena portæ near the pylorus receives the pyloric and gastric veins. The distinctive character of the vessel is that it behaves like an artery, its blood ultimately entering the intralobular plexuses in the liver.

The sources from which the vein receives its blood are as follows :

(1) the stomach, (2) the small and large intestine, except a portion of the anal canal, (3) the pancreas, (4) the spleen, and (5) the gall-bladder.

Summary of the Tributaries of the Vena Portæ.—(1) The superior mesenteric vein, which takes up (*a*) the right gastro-epiploic, (*b*) the pancreatico-duodenal, (*c*) the rami intestini tenuis, (*d*) the ileo-colic, (*e*) the right colic, and (*f*) the middle colic. (2) The splenic vein, which takes up (*a*) the gastric vasa brevia, (*b*) the left gastro-epiploic, (*c*) many pancreatic veins, and (*d*) the inferior mesenteric (as a rule), which in turn takes up the superior hemorrhoidal, sigmoid, and left colic veins. (3) The pyloric vein. (4) The gastric vein. (5) The cystic vein.

The portal vein and its tributaries are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Development of the Vena Portæ. — The *lower portion* of the vein results from the union of the two vitelline veins. The *upper portion* is developed from the left half of the lower venous ring and the right half of the upper venous ring, formed by the vitelline veins around the primitive duodenum.

For a description of the **common bile-duct**, see p. 665.

Kidneys.—The kidneys are two in number, right and left, and are situated deeply at the posterior part of the abdomen, where they lie behind the peritoneum. They chiefly occupy portions of the epigastric and hypochondriac regions, but also extend slightly into the umbilical and lumbar regions. Relatively to the vertebral column they extend from the level of the upper border of the last thoracic vertebra to about the centre of the body of the third lumbar, the right kidney being usually somewhat lower than the left. The long axis of each organ is directed downwards and slightly outwards, so that their upper ends are rather nearer the middle line than the lower. The superior limit of the right kidney is usually the lower border of the eleventh rib, whilst that of the left is usually the upper border of the eleventh rib. Inferiorly the organs approach the iliac crests, from which they are distant about 2 inches, the right being the nearer of the two. Each kidney is surrounded by a quantity of areolar and adipose tissues, constituting the adipose capsule, which, along with the adjacent viscera, anchors the organ. The length of a kidney is about 4 inches, the breadth about 2½ inches, and the thickness about 1¼ inches. The right kidney is usually shorter and broader than the left. The weight of the organ is about 5½ ounces. In form the kidney is bean-shaped. It presents two smooth surfaces, two extremities, and two borders. The anterior surface looks outwards as well as forwards, and presents important visceral impressions, whilst the posterior surface looks inwards as well as backwards, and presents muscular impressions. The extremities are enlarged and round, the superior more so than the inferior, the latter often assuming a somewhat pointed appearance. The external border has an inclination backwards, and is convex and free. The internal border has an inclination forwards, is concave, and is connected with the renal vessels and the pelvis of the kidney.

Relations—*Anterior Surface of the Right Kidney.*—This surface is overlapped by the right suprarenal capsule for a very short distance at its upper and inner part. It presents three visceral areæ—hepatic, duodenal, and colic. The *hepatic area* lies somewhat obliquely, and occupies about the upper two-thirds, being in contact with the impressio renalis on the under surface of the right lobe of the liver.

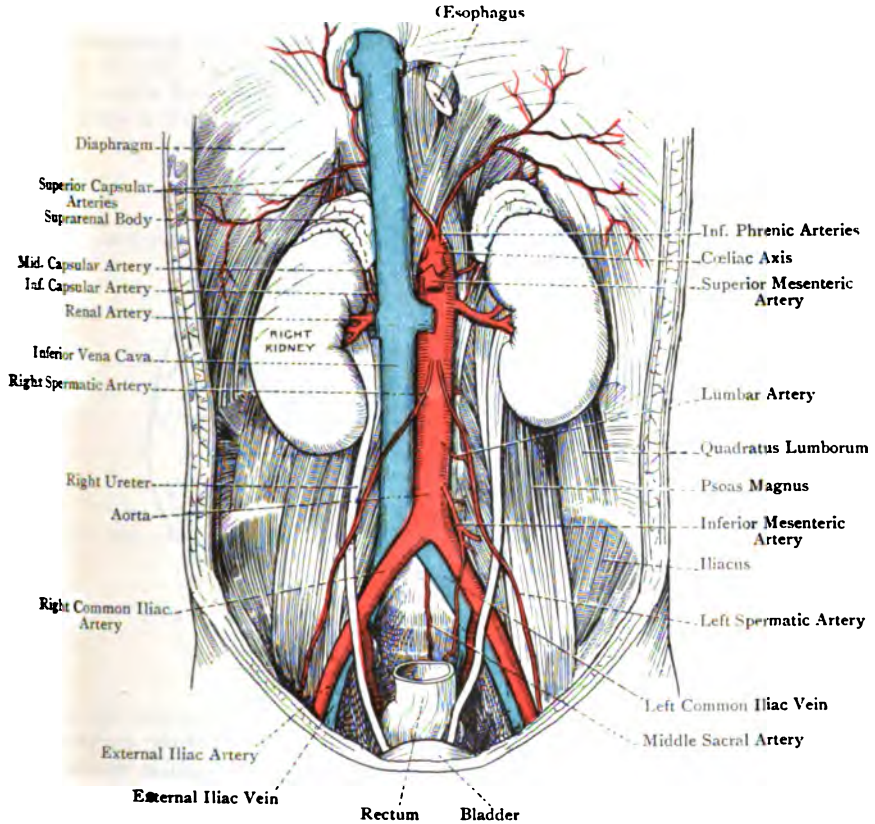


FIG. 312.—DISSECTION OF THE POSTERIOR ABDOMINAL WALL.

It is covered by peritoneum. The *duodenal area* corresponds with an elongated narrow strip lying close to the hilum, and reaching a little above and below it. It is in contact with the posterior wall of the second part of the duodenum, both being destitute of peritoneum. The *colic area* lies below the hepatic, and, like it, is oblique. It is in contact with the upper end of the ascending colon and the hepatic flexure without the intervention of peritoneum. Between the lower part of the duodenal and the colic impression,

that is, at the lower and inner part of the anterior surface, there is a small area covered by peritoneum which is in contact with a portion of the small intestine.

Anterior Surface of the Left Kidney.—This surface is overlapped by the left suprarenal capsule for a very short distance at its upper and inner part. It presents four visceral areæ—splenic, gastric, pancreatic, and colic. The *splenic area* is situated at the upper and outer part, close to the external border, and is in contact with the renal surface of the spleen, the peritoneum of the great cavity intervening. The *gastric area*, somewhat triangular, lies at the upper end, between the splenic and capsular areæ, and above the pancreatic area. It is in contact with the postero-inferior surface

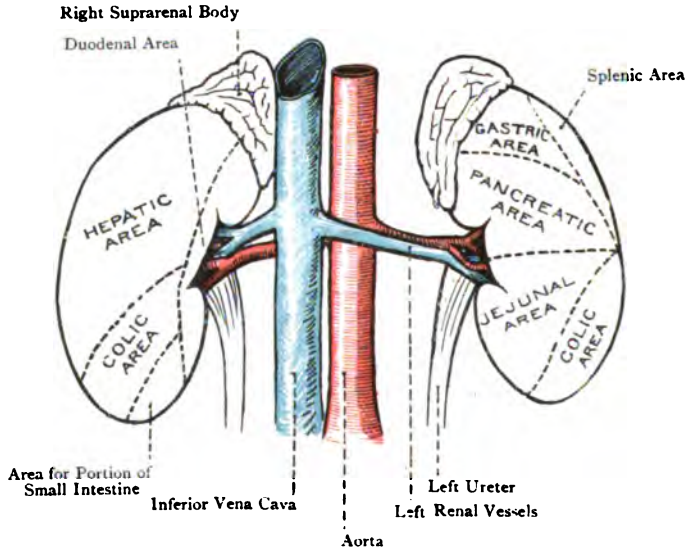


FIG. 313.—THE VISCERAL AREÆ OF THE KIDNEYS
(In this case the right renal vein was higher than usual).

of the stomach with the intervention of the peritoneum of the small sac. The *pancreatic area* lies transversely below the gastric area, and extends as low as about the centre of the hilum. It is in relation with the posterior surface of the body of the pancreas and the splenic vessels, without peritoneum. The *colic area* is situated at the lower and outer part, and is in contact with the splenic flexure and the commencement of the descending colon, without peritoneum. At the lower and inner part there is a small area covered by peritoneum, which is related to a part of the jejunum.

Posterior Surface.—This surface is readily recognised by observing the posterior position of the pelvis of the kidney at the

hilum, with which it coincides. The inner portion of it rests upon (*a*) the psoas magnus and its sheath, and (*b*) the crus of the diaphragm. The outer portion rests, from above downwards, upon (*a*) the twelfth rib (in the case of the left kidney the eleventh rib also), (*b*) the diaphragm, and (*c*) the quadratus lumborum, covered

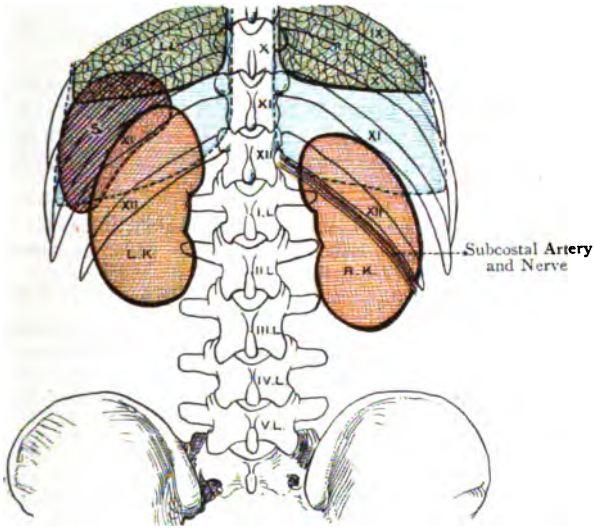


FIG. 314.—DIAGRAM SHOWING THE RELATIONS OF THE KIDNEYS FROM BEHIND.

R.L. Right Lung
L.L. Left Lung
S. Spleen
R.K. Right Kidney
L.K. Left Kidney
IX. Ninth Rib
X. Tenth Rib
XI. Eleventh Rib
XII. Twelfth Rib
I.L. First Lumbar Vertebra
II.L. Second Lumbar Vertebra
III.L. Third Lumbar Vertebra
IV.L. Fourth Lumbar Vertebra
V.L. Fifth Lumbar Vertebra

by the anterior lamina of the lumbar aponeurosis. An important surgical relation of the upper part of this division of the posterior surface is that the pleura, in descending between the diaphragm and the twelfth rib, lies behind the kidney. Three nerves pass downwards and outwards behind the organ, namely, the subcostal, ilio-hypogastric, and inguinal.

The *superior extremity* is capped by the suprarenal capsule, which also extends for a little over the anterior surface and adjacent portion of the internal border.

The *external border*, which is convex, rests on the posterior aponeurosis of the transversalis abdominis. The external border of the right kidney, over about its upper two-thirds, is in contact with the liver, whilst the external border of the left kidney at its upper end is in contact with the spleen.

The *internal border* of the right kidney lies very near the

inferior vena cava, whilst that of the left is situated fully 1 inch from the aorta. This border is concave, and presents a longitudinal fissure, called the *hilum*, which extends over about its middle third. It presents two somewhat thick lips, anterior and posterior, and it leads to a cavity within the organ, called the *sinus*. It transmits the following structures in order from before backwards: the branches of the renal vein, the branches of the renal artery, with branches of the renal sympathetic plexus and lymphatics, and the pelvis of the kidney.

The side to which a kidney belongs may be ascertained in the following way: if the organ is held with that end downwards towards which the ureter is naturally inclined, and that surface backwards which coincides with the pelvis at the hilum, the convex border will then indicate the side to which the organ belongs.

Varieties—Form.—The kidneys may be much elongated, or somewhat round, or triangular. The lobulated condition, which is characteristic of the kidney in early life, may persist in the adult.

Size.—One kidney may be diminished in size, in which cases there is a proportionate increase in the other organ.

Position.—It is very rare to find the kidneys higher than usual, but one or both not infrequently extend into the iliac fossa, or over the pelvic brim.

Number—*Diminution.*—One kidney (usually the left) may be entirely suppressed, in which cases the solitary kidney usually occupies its normal position, and may, or may not, be of large size. *Increase.*—The number may be increased to three, the additional organ being lateral, or median, in position.

Horseshoe Kidney.—This condition is brought about by the fusion of the lower parts of the organs, the connecting band of renal substance extending across the vertebral column.

Preternatural Mobility. — The kidney is usually anchored in its normal position by its capsule and the adjacent viscera, but it is sometimes movable, which may be due to one of two causes: (1) the capsule may be very loose, giving rise to the condition known as **movable kidney**; or (2) the organ may be attached to the posterior abdominal wall by a peritoneal fold, called the *meso-nephron*, in which case the condition known as **floating kidney** occurs, this being said to be more frequent on the right side.

For the structure and development of the kidney, see pp. 766, 777.

Ureter.—The ureter is the excretory duct of the kidney, and it conveys the urine to the bladder. It is a cylindrical, thick-walled tube, like a goose-quill, its average length being about 12 inches, and its diameter about $\frac{1}{5}$ inch. The ureter proper commences towards the lower end of the kidney, where it is the continuation of the pelvis, and it terminates in the bladder. The **pelvis** is funnel-shaped and flattened from before backwards. It lies partly in the sinus, where it receives the calices, and partly outside the hilum, where it lies behind the other transmitted structures. Its direction is downwards and inwards, and, having become narrow, it passes into the ureter proper towards the lower end of the kidney.

The **ureter proper** passes downwards and inwards behind the peritoneum, in contact with the posterior abdominal wall. It rests at first upon the psoas magnus and its sheath, being here crossed superficially by the spermatic (or ovarian) vessels, which

are taking a course downwards and outwards, and deeply by the genito-crural nerve, which is taking a similar course. In this part of its course the right duct has the inferior vena cava near it on its inner side, whilst the left duct has the aorta on its inner side, but at some little distance. The ureter next crosses the terminal part of the common iliac artery (or the commencement of the external iliac), after which it enters the pelvic cavity, the right ureter being crossed by the lower part of the root of the mesentery proper, and the left by a portion of the pelvic meso-colon. In the pelvis the ureter passes downwards and forwards in front of the internal iliac artery to the outer wall of the pelvis, lying beneath the peritoneum, and crossing internally the obturator vessels and nerve, and the obliterated hypogastric artery. It subsequently passes inwards to the bladder, being crossed internally by the vas deferens. Having arrived at the lateral or ureteric angle of the bladder, it commences to pierce the vesical wall anterior to the upper free end of the vesicula seminalis, being here about 2 inches distant from its fellow, and about 1½ inches from the base of the prostate gland. It now pursues an oblique course through the wall of the bladder, lying in it for about ¾ inch, and it finally opens into the interior by a very small slit-like aperture placed obliquely at one angle of the base of the internal trigone, where it is distant from its fellow and from the urethral orifice by about 1¼ inches. In the female the ureter, in its pelvic course, passes along the side of the cervix uteri and upper part of the vagina.

Varieties.—(1) The pelvis may be absent, its place being taken by two, or three, tubes. (2) **Double Ureter.**—The foregoing tubes may remain separate for some distance beyond the hilum, or even as low as the bladder, thus giving rise to a double ureter. A triple ureter is extremely rare. (3) **Dilated Ureter.**—This condition is liable to result in such cases as urethral stricture, enlarged prostate, and vesical calculus.

For the structure of the ureter, see p. 775.

Suprarenal Capsules or **Bodies.**—The suprarenal capsules (adrenals) are two in number, right and left, and are situated in the epigastric region. Each is compressed from before backwards, and broad from side to side. It is set upon the superior extremity of the corresponding kidney, to which it is bound by connective tissue. Each capsule encroaches upon the adjacent parts of the anterior surface and internal border of the kidney, the left being mainly situated upon the internal border. The dimensions of the organ are so variable that they can only be stated approximately as follows: the height is about 1½ inches, and the breadth rather less than 2 inches. The weight, on an average, is about 2 drachms.

The **right capsule** is rather smaller than the left, and is triangular. It is wedged in between the diaphragm and the posterior surface of the right lobe of the liver, and its surfaces are anterior and posterior, the former having an inclination outwards, and the latter inwards. The *anterior surface*, close to the inner border, is in contact with the inferior vena cava, and elsewhere it is related to the pos-

terior surface of the right lobe of the liver. At its upper and inner part there is a small fissure, called the *hilum*, through which the right suprarenal vein emerges. The peritoneum gives a partial covering to this surface at its lower part. The *posterior surface* is in contact with the diaphragm and the upper part of the anterior surface of the right kidney. The right semilunar ganglion lies on the inner side of the right capsule.

The **left capsule** is somewhat semilunar. The *anterior surface* is related above to the postero-inferior surface of the stomach, with the intervention of the small sac, which furnishes it with a peritoneal covering. Below this it is related to the posterior surface of the body of the pancreas and the splenic vessels, without peritoneum. The hilum, through which the left suprarenal vein emerges, is situated at the lower and inner part of this surface. The *posterior surface* at its upper part is in contact with the left crus of the diaphragm, and, below, it rests upon the upper and inner part of the front of the left kidney, as well as upon its internal border.

For the structure and development of the suprarenal capsule see pp. 765, *et seq.*

Abdominal Aorta.—The abdominal aorta commences at the aortic opening of the diaphragm on a level with the lower border of the body of the twelfth thoracic vertebra, where it lies in the middle line, and it usually terminates opposite the centre of the body of the fourth lumbar vertebra, a finger's breadth to the left of the middle line, by dividing into the right and left common iliac arteries. The position of the bifurcation may be indicated in one of two ways, as follows: (1) by taking a point fully 1 inch below the umbilicus and a finger's breadth to the left of the linea alba; or (2) by taking a point in the line which connects the highest parts of the iliac crests a finger's breadth to the left of where it intersects the linea alba. The bifurcation may take place a little lower down or higher up than the normal level. The length of the vessel is about 5 inches. It occupies the epigastric and umbilical regions, where it lies very deeply behind the peritoneum, and its direction is downwards with a slight inclination to the left.

Relations—*Anterior.*—The direct anterior relations, from above downwards, are as follows: the origins of the inferior phrenic arteries, the cœliac axis, cœliac glands, and solar plexus, the ascending layer of the transverse meso-colon, the pancreas and splenic vein, the root of the superior mesenteric artery, the third part of the duodenum and left renal vein, the origins of the spermatic (or ovarian) arteries, the aortic plexus, the median group of lumbar glands, the peritoneum of the general cavity, and the origin of the inferior mesenteric artery. The more remote anterior relations are the gastro-hepatic omentum, stomach, transverse colon with its meso-colon, coils of the small intestine, root of the mesentery proper, and gastro-colic omentum. *Posterior.*—The disc between the twelfth thoracic and first lumbar vertebræ, the bodies and discs of the upper four lumbar vertebræ, and

the anterior common ligament, the left lumbar veins, and the origins of the lumbar and middle sacral arteries. *Right.*—The right crus of the diaphragm, with the receptaculum chyli and right vena azygos lying deeply between the vessel and the right crus, the former being nearest the aorta, and slightly covered by it; and the inferior vena cava. *Left.*—The left crus of the diaphragm, the left semi-

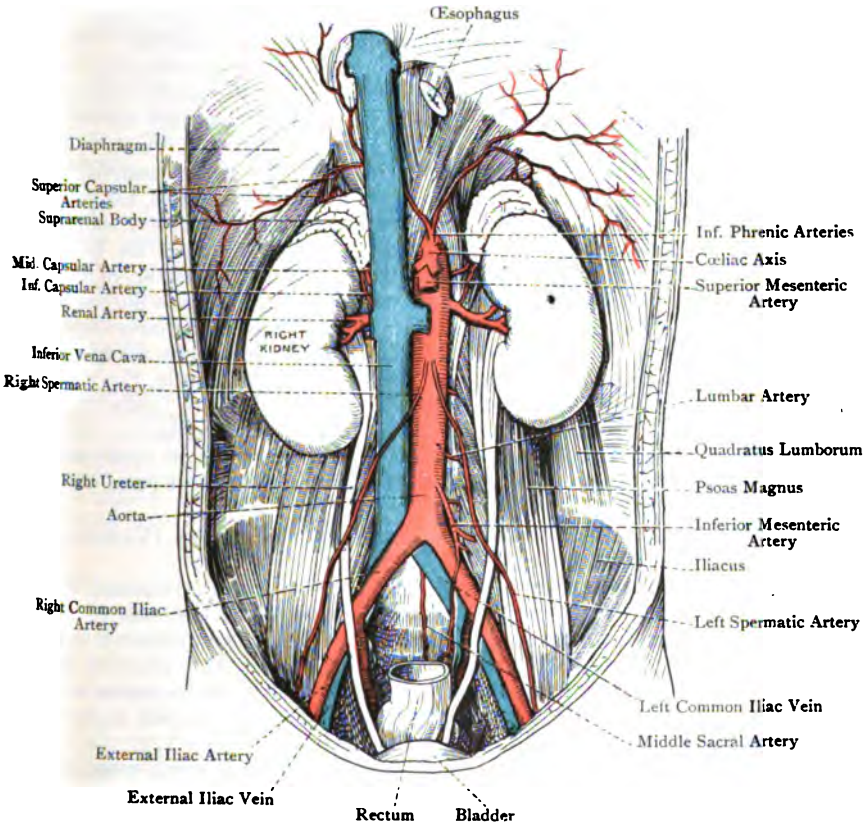


FIG. 315.—DISSECTION OF THE POSTERIOR ABDOMINAL WALL.

lunar ganglion, the terminal portion of the third part of the duodenum (ascending part of Treves), and the left sympathetic gangliated cord.

Branches.—These are nine in number, and are arranged in two groups, *visceral* and *parietal*, four of them being single, and five arranged in pairs. The four single branches are the cœliac axis, superior mesenteric, inferior mesenteric, and middle sacral. The five pairs are the inferior phrenic, middle capsular, renal, spermatic

(ovarian in the female), and the lumbar. Excluding the lumbar arteries, the order of origin of the branches is as follows: (1) inferior phrenic, (2) cœliac axis, (3) superior mesenteric and (4) middle capsular, both on same level, (5) renal, (6) spermatic (or ovarian), (7) inferior mesenteric, and (8) middle sacral. In what follows the letter P after an artery signifies parietal, and V visceral.

The **inferior phrenic arteries** (P) are two in number, right and left, and they are called *inferior* to distinguish them from the *superior* phrenic of the internal mammary, right and left. They arise, either separately or by a common trunk, from the front of the aorta, whenever the vessel has passed through the aortic opening of the diaphragm. They at once diverge, each passing outwards and upwards over the crus of the diaphragm, the right vessel lying behind the inferior vena cava, and the left behind the œsophagus. Each ends by dividing into two branches, anterior and external. The *anterior branch* passes forwards and inwards in a curved manner in front of the central tendon, and anastomoses with its fellow of the opposite side, and the superior phrenic and musculo-phrenic of the internal mammary. The *external branch* passes outwards, and anastomoses with the musculo-phrenic and the lower intercostal arteries. Each inferior phrenic artery furnishes a *superior capsular branch* (or branches) to the suprarenal capsule, the right vessel also giving off a few branches to the inferior vena cava, whilst the left supplies a few branches to the œsophagus.

The *right* **inferior phrenic vein** opens into the inferior vena cava, and the *left* terminates in the left suprarenal vein, left renal vein, or inferior vena cava.

The **cœliac axis** (V) and **superior mesenteric artery** (V) will be found described on pp. 673, 679.

The **middle capsular arteries** (V) are of small size, and are two in number, right and left, each arising from the side of the aorta on a level with the origin of the superior mesenteric artery. The vessel passes outwards and upwards over the crus of the diaphragm to the suprarenal capsule, in which it anastomoses with the superior capsular of the inferior phrenic and the inferior capsular of the renal.

The *right* **suprarenal vein** opens into the inferior vena cava, and the *left* into the left renal vein.

The suprarenal veins originally open into the cardinal veins. The right suprarenal vein becomes transferred to the upper segment of the inferior vena cava (above the right renal vein). The left suprarenal vein, after the obliteration of the adjacent portion of the left cardinal vein, becomes transferred to the left renal vein.

The **renal arteries** (V) are remarkable for their large size, and are two in number, right and left. They arise from the side of the aorta about ½ inch below the superior mesenteric on a level with the body of the first lumbar vertebra, the right artery being usually a little lower than the left. They form right angles with

the aorta, and cross the crura of the diaphragm on their way to the hila of the kidneys, the right vessel passing behind the inferior vena cava, second part of the duodenum, and head of the pancreas, whilst the left passes behind the body of the pancreas. Each vessel has its own vein in front of it, and the aortico-renal ganglion lies over its root. On approaching the renal hilum each vessel divides into three or four branches, one of which usually passes behind the pelvis of the kidney, whilst the others lie between the renal vein in front and the pelvis behind. For the subsequent distribution of the branches in the kidney, see p. 771.

Before breaking up into its proper renal branches the vessel gives off an *inferior capsular artery* to the suprarenal capsule, *peri-renal branches* to the capsule, and *ureteric* to the upper part of the ureter.

Differences between the Renal Arteries.—(1) The right artery is rather lower than the left. (2) The right is rather longer than the left, on account of the inclination of the aorta to the left of the middle line. (3) The right passes behind the inferior vena cava, second part of the duodenum, and head of the pancreas, whilst the left passes behind the body of the pancreas.

Varieties.—1. Very often there is an *accessory renal artery* present, arising close to the main vessel, and usually above it. 2. The renal artery may divide into its renal branches close to its origin. 3. There may be an *aberrant renal artery*, which may arise from the inferior phrenic, spermatic (or ovarian), inferior mesenteric, common or external iliac, or middle sacral. 4. In cases of variations, or even in the normal condition, one or more of the renal branches may fail to enter the hilum, and may pierce the kidney on its anterior surface, or near the upper or lower end.

The **renal veins,** like the arteries, are of large size. Each lies in front of its artery, and receives tributaries from the adipose tunic and the upper part of the ureter. The vessels are tributaries of the inferior vena cava, which they join almost at a right angle, the left a little higher than the right. The left vein crosses in front of the aorta, taking up in its course the left suprarenal and left spermatic (or ovarian) veins. In some cases there is a single semilunar valve at the lower part of the opening of each renal vein into the inferior vena cava.

Difference between the Renal Veins.—(1) The left vein is longer than the right, on account of the position of the inferior vena cava on the right side. (2) The left is rather higher than the right. (3) The left crosses in front of the aorta. (4) The left receives the left suprarenal and left spermatic (or ovarian) veins.

The renal veins originally open into the cardinal veins. Subsequently the right renal vein opens into the junction of the upper and lower segments of the inferior vena cava. When the left cardinal vein becomes obliterated, in great part the left renal vein becomes continuous with the left division of the primitive inferior vena cava. The mesial portion of the left renal vein is developed from the left division of the primitive inferior vena cava.

The **spermatic arteries** (V) are two in number, right and left, and they arise from the front of the aorta about 1 inch below the renal arteries. If they arise separately they are close to each other, but they sometimes spring by a common trunk. They are long, slender, somewhat tortuous vessels, which at once diverge, each passing obliquely downwards and outwards behind the peritoneum. In this course the vessel rests upon the aorta for a short distance, and then upon the psoas magnus and its sheath, where it crosses the ureter. The right artery passes in front of the inferior vena cava and behind the terminal part of the ileum, whilst the left passes behind the iliac colon. Subsequently the artery, on its way to the internal abdominal ring, lies upon the terminal part of the external iliac. At the internal ring it is joined by the vas deferens to form, with other structures, the spermatic cord. The vessel then passes through the internal abdominal ring, along the inguinal canal, and through the external abdominal ring into the scrotum, where it divides into testicular and epididymal branches. In the abdomen the spermatic artery furnishes ureteric branches to the ureter, and in the scrotum it gives off cremasteric branches to the coverings of the spermatic cord, which anastomose with the cremasteric branch of the deep epigastric. During fœtal life the vessel is very short, and takes a transverse course to the testis, which is then lying below and behind the kidney. As the testis, however, descends into the scrotum the vessel gradually becomes much elongated.

Varieties.—(1) One or both spermatic arteries may be absent, in which cases the testis is supplied chiefly by the deferential artery. (2) A spermatic artery may arise from a renal artery.

The **spermatic veins** spring from the pampiniform plexus of the spermatic cord at the internal abdominal ring, and are at first two in number on each side, which lie one on either side of the corresponding artery. They subsequently unite to form a single vessel, which on the *right* side opens at an acute angle into the inferior vena cava, and on the *left* at a right angle into the left renal vein. There is usually a valve at the point of termination of each vein, though this may be absent. In the left spermatic vein, where it joins the left renal vein, the valve directs the current of blood entering by the spermatic vein in the direction of the inferior vena cava. It also prevents the blood in the left renal vein from entering the spermatic vein by directing the current over the mouth of the latter vessel. The *left* spermatic vein is rather longer than the right.

The spermatic veins originally open into the cardinal veins. The *right* spermatic vein opens into that portion of the right cardinal vein which persists as the lower segment of the permanent inferior vena cava. The upper part of the *left* spermatic vein is formed from that portion of the left cardinal vein which lies immediately below the left renal vein. In this manner the difference in the mode of termination of the two spermatic veins in the adult is accounted for.

The **ovarian arteries** (V), in the female, take the place of the spermatic arteries in the male, and their course and relations in the abdomen correspond with those of the spermatics. The ovarian arteries are, however, shorter than the spermatics, and they do not pass out through the inguinal canal; but enter the pelvis by crossing the commencement of the external iliac artery. In the pelvis each vessel becomes very tortuous, and passes between the two layers of the broad ligament of the uterus to be distributed to the ovary. In the abdomen the artery supplies branches to the ureter, and in the pelvis it furnishes the following offsets: *tubal* to the Fallopian tube; a *uterine branch* to the side of the uterus; and a *ligamentous branch* to the round ligament of the uterus, which it accompanies as far as the inguinal canal. The ovarian arteries, like the spermatic, are very short and transverse in direction during fœtal life, when the ovary occupies a position similar to that of the testis. They, however, gradually become elongated as the ovary descends to its future abode in the pelvis.

The **ovarian veins** spring from the ovarian or pampiniform plexus between the two layers of the broad ligament, close to the ovary. After emerging therefrom their subsequent course and mode of termination resemble those of the spermatic veins.

For the **inferior mesenteric artery** (V) and **vein,** see p. 684; for the **middle sacral artery** (P) and **vein,** see p. 806; and for the **lumbar arteries** (P) and **veins,** see p. 725.

Inferior Vena Cava.—The inferior vena cava commences opposite the upper border of the body of the fifth lumbar vertebra a little to the right of the middle line, where it is formed by the union of the right and left common iliac veins, and it terminates at the postero-inferior angle of the right auricle of the heart. It ascends along the right side of the aorta, resting upon the anterior and right aspects of the lumbar vertebræ as high as the level of the second. Beyond this point it diverges from the aorta, and is supported by the right crus of the diaphragm. It then occupies the caval fossa on the posterior surface of the right lobe of the liver. On leaving this fossa it passes through the caval opening in the central tendon of the diaphragm, and, almost immediately thereafter, it opens into the postero-inferior angle of the right auricle of the heart. As the vein passes through the caval opening its walls are connected with the margins of that opening, and so the patency of the vessel is maintained.

Relations—*Anterior.*—From below upwards, the right common iliac artery, lower part of the root of the mesentery proper, right spermatic (or ovarian) vessels, third part of the duodenum, head of the pancreas, origin of the vena portæ, first part of the duodenum, foramen of Winslow, and posterior surface of the liver. *Posterior.*—The bodies, discs, and anterior common ligament of the lower three lumbar vertebræ, the corresponding right lumbar vessels, inner border of the right psoas magnus and its sheath,

right sympathetic gangliated chain, right renal artery, right semilunar ganglion, right crus of the diaphragm, right suprarenal capsule, and right inferior phrenic artery. *Right.*—From below upwards, the right ureter and the internal border of the right kidney.

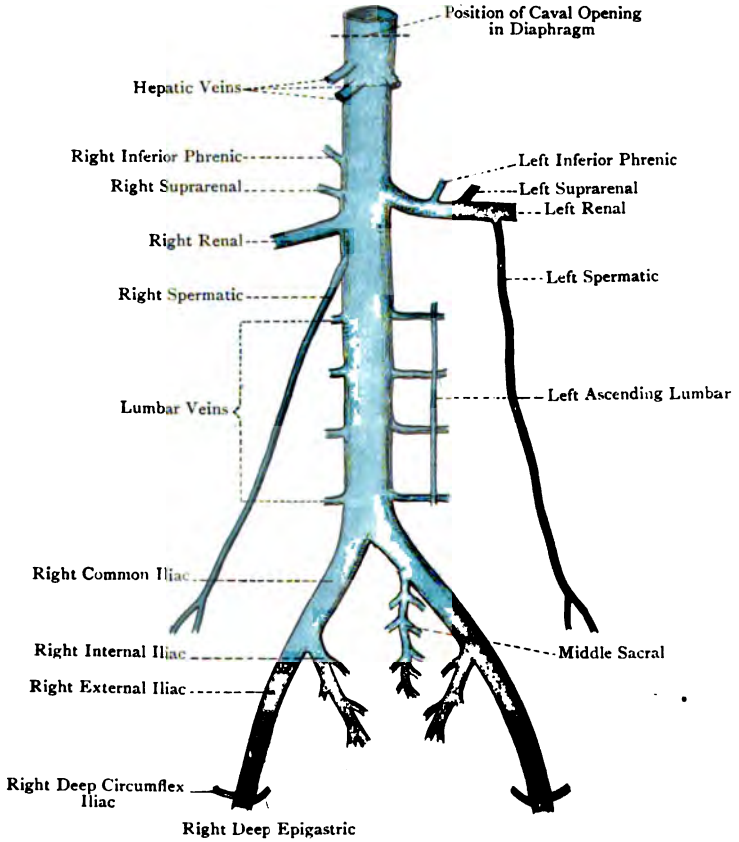


FIG. 316.—SCHEME OF THE INFERIOR VENA CAVA AND ITS TRIBUTARIES.

Left.—From below upwards, the aorta and the right crus of the diaphragm.

Tributaries.—These are as follows: the right and left common iliac veins, right and left lumbar veins, the right spermatic (or ovarian) vein, the right and left renal veins, the right suprarenal vein, the right inferior phrenic vein (and sometimes the left), and the hepatic veins at the caval fossa of the liver.

Chief Varieties.—(1) The vessel may be found on the left side of the aorta in its lower part, in which cases it subsequently crosses that vessel to take up

its usual position on its right side. This may be due to a transposition of viscera, or to a permanent patency of the lower part of the left cardinal vein of fœtal life. (2) The inferior vena cava, in very rare cases, may terminate in a large right azygos vein, and, through means of that, in the superior vena cava. Under these circumstances the hepatic veins open into the right auricle of the heart.

Development. — The *upper segment* is developed from the primitive inferior vena cava and its right division. The *lower segment* is developed from the portion of the right cardinal vein which lies between the right extremity of the primitive transverse iliac vein and the right renal vein.

Diaphragm—*Origin*—**Sternal Portion.**—By two fleshy slips from the back of the ensiform process close to its lower end. **Costal Portion.**—By six fleshy slips, at either side, from the inner surfaces of the lower six costal cartilages, which interdigitate with slips of the transversalis abdominis. **Vertebral Portion.**—From the external and internal arcuate ligaments, and the fronts of the bodies of lumbar vertebræ, as well as the intervertebral discs and anterior common ligament, by two crura, the right crus reaching usually as low as the disc between the third and fourth lumbar bodies, and the left as low as the disc between the second and third.

Insertion.—The central tendon on all sides.

Nerve-supply.—The right and left phrenic nerves, each of which springs chiefly from the anterior primary division of the fourth cervical nerve, and usually receives a branch from the third, and sometimes from the fifth. Each phrenic nerve, on approaching the diaphragm, divides into branches which pierce its muscular part separately in front of the central tendon, and are distributed on the abdominal surface of the muscle. In the right half of the muscle a communication takes place between the right phrenic nerve and the right inferior phrenic sympathetic plexus, a small ganglion, called the *ganglion diaphragmaticum*, being situated at the place of communication. A similar connection is established on the left side, but no ganglion is present.

Arterial Supply. — (1) The inferior phrenic branches of the abdominal aorta ; (2) the superior phrenic (comes nervi phrenici) and musculo-phrenic, both branches of the internal mammary of each side ; (3) the phrenic branch of the superior epigastric of the internal mammary of each side ; and (4) branches from the lower intercostal arteries.

Lymphatics.—These pass to the sternal, anterior mediastinal, posterior mediastinal, intercostal, and lumbar glands.

Action.—The diaphragm by its contraction increases the vertical diameter of each half of the thorax, and is therefore a muscle of inspiration. The middle portion of the central tendon is fixed by reason of the fibrous portion of the pericardium, which is implanted into it, being connected above with the deep cervical fascia. The fleshy portion, however, becomes flattened, and descends towards the abdomen, displacing the viscera, and so increasing the vertical

diameter of each half of the thorax. The diaphragm also elevates the lower ribs, except the last.

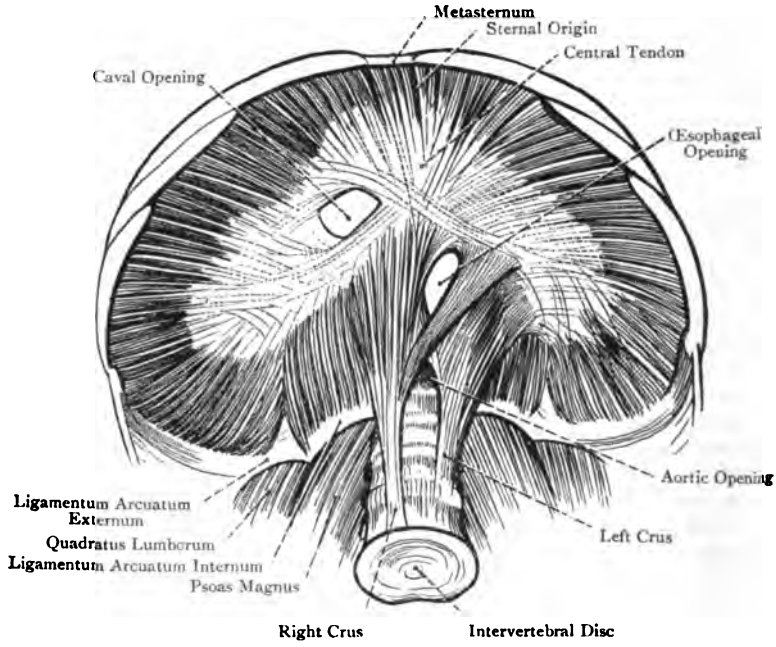


FIG. 317.—THE DIAPHRAGM (INFERIOR VIEW).

The muscular fibres pass in an arched manner upwards and inwards to the central tendon, upon which they converge from all points. The sternal portion is separated on either side from the costal portion by a small interval occupied by areolar tissue, through which the superior epigastric vessels and some of the superficial lymphatics of the upper surface of the liver pass. Above and below this interval are the pleura and peritoneum respectively. In this situation a diaphragmatic hernia may take place, involving one or other of the abdominal viscera. Between the lowest costal fibres and the corresponding external arcuate ligament there is sometimes another areolar interval of small size. The **crura** are strong, thick musculo-tendinous bundles disposed vertically, the left being the smaller, shorter, and more posterior of the two. Each crus is fleshy externally, and strongly tendinous internally, the lower extremity of each being entirely tendinous. On a level with the lower border of the body of the twelfth thoracic vertebra the inner tendinous fibres of the crura are connected by a fibrous band, called the middle arcuate ligament, which lies in front of the aorta. The muscular fibres of the crura pass upwards in a diverging manner to be inserted into the posterior border of the central tendon. The innermost muscular fibres on either side, reinforced by fibres springing from the middle arcuate ligament, decussate before reaching the central tendon and enclose between them the œsophageal opening. In the decussation the bundle derived from the right crus passes in front of that from the left, which latter is of small size.

The **central tendon** is also called the *cordiform* or *trefoil* tendon. It is much elongated from side to side, convex in front, and con-

cave behind. It is divided into three lobes or alæ, right, middle, and left, of which the right is the largest, and the left the smallest and narrowest. The separation into lobes is indicated by two small notches situated in the course of the anterior convex border.

The diaphragm presents three foramina, namely, aortic, caval, and œsophageal.

The **aortic opening** is situated in the middle line between the upper portions of the crura, and in front of the disc between the bodies of the twelfth thoracic and first lumbar vertebræ. It is bounded on either side by a crus, in front by the middle arcuate ligament, and behind by the anterior common ligament of the

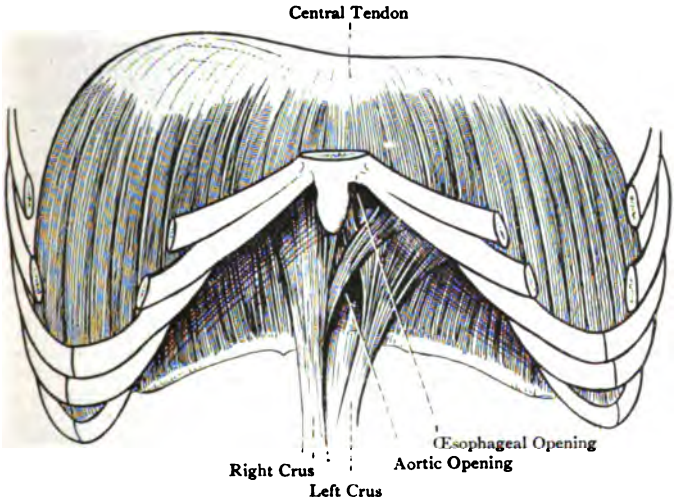


FIG. 318.—THE DIAPHRAGM (SUPERIOR VIEW)

(After L. Testut's "Anatomie Humaine").

vertebral column. It is therefore not really an opening in the diaphragm, but is situated behind it. It transmits the aorta, thoracic duct, and right azygos vein, in this order from left to right.

The **caval opening** (*foramen quadratum*) is situated in the central tendon close to its posterior border, and at the junction of the right and middle lobes. It is somewhat four-sided with rounded angles, and transmits the inferior vena cava and some of the deep lymphatics of the liver.

The **œsophageal opening** is situated in the fleshy part of the muscle. It is elliptical, and lies in front, and a little to the left, of the aortic opening, being separated from it behind by the inner decussating fibres of the crura. It transmits the œsophagus, the

right and left pneumogastric nerves, and the œsophageal branches of the gastric artery.

In addition to the foregoing foramina, the diaphragm presents certain small fissures, as follows: each crus is pierced by the great and small splanchnic nerves, and sometimes by the least. The left crus is also pierced by the lower left azygos vein. The musculo-phrenic artery pierces the costal portion, and the branches of the phrenic nerve are also transmitted through the muscle.

The **arcuate ligaments** are five in number, as follows: external, right and left; internal, right and left; and middle. The **external arcuate ligament** is a thickening of the upper part of the anterior wall of the sheath of the quadratus lumborum, and extends from the last rib to the tip of the transverse process of the first lumbar vertebra. The subcostal artery and nerve pass downwards and outwards behind it. The **internal arcuate ligament** is a thickening of the upper part of the sheath of the psoas magnus, and extends from the tip of the transverse process of the first lumbar vertebra to the side of its body. The gangliated cord of the sympathetic passes into the abdomen behind it, and sometimes the least splanchnic nerve. The **middle arcuate ligament** is a fibrous band which connects the innermost tendinous fibres of the crura on a level with the lower border of the body of the twelfth thoracic vertebra, and it arches over the aorta.

Relations of the Diaphragm—*Superior.*—The right and left pleuræ with the lungs, and the pericardium with the heart. *Inferior.*—The peritoneum, except opposite the uncovered area of the posterior surface of the liver; the liver with its suspensory, coronary, and right and left lateral or triangular ligaments; the stomach; spleen; pancreas; kidneys; and suprarenal capsules.

Development.—The diaphragm is of mesoblastic origin, and is developed in two parts, ventral and dorsal. The *ventral part*, which is the first to appear, is developed from the upper stratum of the *septum transversum* of His, and it ends posteriorly in a free projecting edge. It shuts off a considerable part of the thorax from the abdomen, leaving two spaces, one on each side of the primitive alimentary tube, which are destined to form the pleural cavities. The *dorsal part* consists of two divisions, which grow inwards and forwards from the lateral and posterior walls of the embryo, and fuse with the posterior free edge of the ventral part, thus completing the diaphragm. This fusion however, may be incomplete, in which cases a free communication is left between the thoracic and abdominal cavities, through which a diaphragmatic hernia may occur.

Gangliated Cord of the Sympathetic.—This cord enters the abdomen behind the inner portion of the internal arcuate ligament. It then descends along the inner border of the psoas magnus, where it lies *in front of* the bodies of the lumbar vertebræ, and, having passed behind the common iliac artery, it enters the pelvis. The right lumbar cord is under cover of the inferior vena cava, whilst the left lies a little to the left of the aorta, and the lumbar vessels of each side pass beneath the corresponding cord. Each cord usually contains four ganglia.

Branches.—These are arranged in two sets, namely, rami communicantes, and branches of distribution. The *rami communicantes*, which are long, are of two kinds, white and grey, the latter being

the more numerous. The *white* rami are composed of medullated nerve-fibres, and are not more than three in number. They are derived from the anterior primary divisions of the first three lumbar nerves, and proceed to the ganglia. The *grey* rami pass from all four ganglia to join the anterior primary divisions of the five lumbar nerves. Both white and grey rami pass together beneath the fibrous arches of the psoas magnus in company with the lumbar vessels, and the communications with the lumbar nerves are established close to the intervertebral foramina. The *branches of distribution* proceed partly from the ganglia and partly from the connecting cord, and are distributed to the coats of the aorta, the bodies and ligaments of the lumbar vertebræ, and the hypogastric plexus, the last branches crossing the common iliac artery.

Receptaculum Chyli.—This is the dilated commencement of the thoracic duct. It is situated deeply at the upper part of the posterior abdominal wall in front of the bodies of the first and second lumbar vertebræ, where it has the aorta on its left side and slightly in front, and the right azygos vein on its right side. It is overlapped by the right crus of the diaphragm. It is somewhat elliptical, being about $\frac{1}{6}$ inch broad at its widest part, and about 2 inches in length. Superiorly it becomes narrow, and is continued into the thoracic duct, which enters the thorax through the aortic opening of the diaphragm. It receives the following afferent vessels from below upwards: the right and left lumbar lymphatic trunks from the median lumbar glands, which join its lower narrow end; some of the efferent vessels from the lateral lumbar glands; and the intestinal lymphatic trunk (or trunks) from the mesenteric glands, which sometimes takes up the efferent vessels of the cœliac glands, though these may enter the receptaculum chyli independently.

Azygos Veins.—These are three in number, namely, the vena azygos major, or right azygos vein, the vena azygos minor or lower left azygos vein, and the upper left, or accessory, azygos vein.

The **vena azygos major** or **right azygos vein** usually commences in the *right ascending lumbar vein*, which is formed by longitudinal anastomosing branches passing between the lumbar veins in front of the lumbar transverse processes, and so disposed as to form one vein which communicates with the inferior vena cava and with one or other of the following veins of the right side: the common iliac, the internal iliac, the ilio-lumbar, or the lateral sacral. Sometimes, however, the right azygos vein springs from the posterior aspect of the inferior vena cava close to the right renal vein, or from that renal vein itself, or from the first right lumbar vein. It ascends upon the body of the first lumbar vertebra, where it lies on the right side of the receptaculum chyli under cover of the right crus of the diaphragm, and it enters the thorax through the aortic opening of that muscle. For its subsequent course in the thorax, where it terminates in the superior vena cava, see the section of the thorax.

The **vena azygos minor** or **lower left azygos vein** commences in

the *left ascending lumbar vein*, through which it has communications similar to those of the right azygos vein. It may, however, spring from the left renal vein, or the first left lumbar vein. It enters

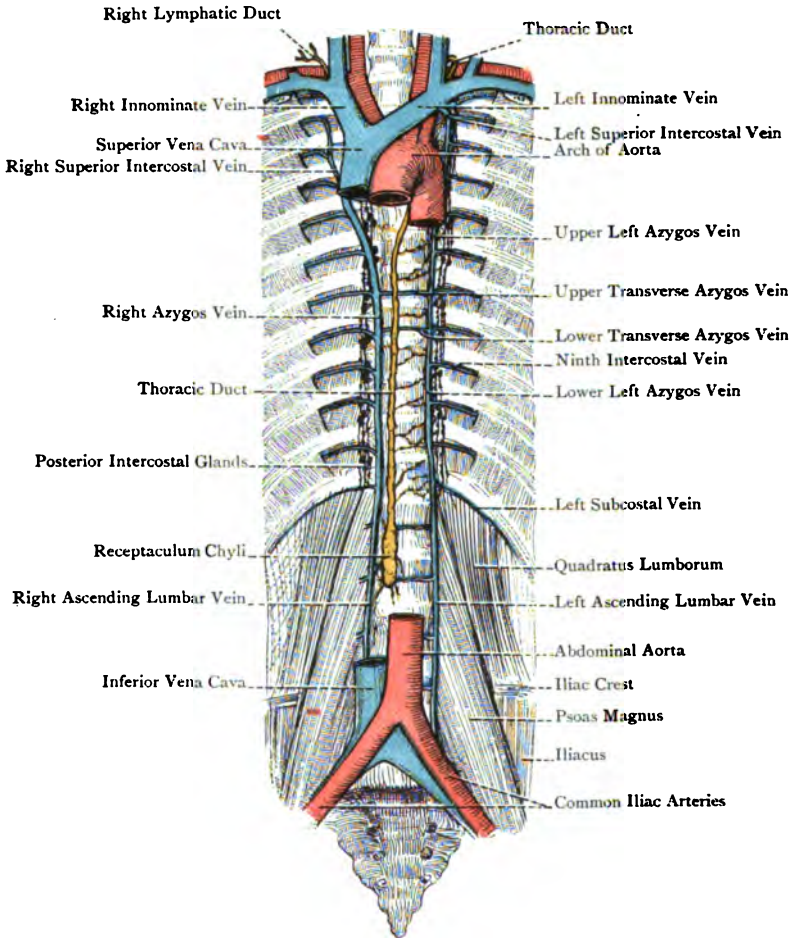


FIG. 319.—THE THORACIC DUCT, AZYGOS VEINS, AND POSTERIOR INTERCOSTAL GLANDS.

the thorax through the left crus of the diaphragm, and subsequently terminates in the right azygos vein.

The right and lower left azygos veins are persistent portions of the right and left cardinal veins of fœtal life.

The right and lower left azygos veins, through their connections with the ascending lumbar veins, establish communications with

the inferior vena cava, and with the common iliac veins or some of their tributaries. They therefore form important channels by which a considerable quantity of blood is returned from the lower limbs and abdominal wall in cases of obstruction of the inferior vena cava.

The upper left, or accessory, azygos vein will be found described in connection with the thorax.

Fasciæ of the Posterior Abdominal Wall—Iliac Fascia.—This fascia covers the iliacus and psoas magnus muscles. Above the level of the iliac crest it is related only to the psoas magnus, and the part covering that muscle is spoken of as the *psoas sheath*. *Superiorly* it forms the internal arcuate ligament, which extends between the tip of the first lumbar transverse process and the side of the body of that vertebra. *Internally* it is attached to (*a*) the intervertebral discs and contiguous margins of the bodies of the lumbar vertebræ, and (*b*) the fibrous arches over the lumbar vessels opposite the centre of each lumbar body. *Externally*, near the tips of the lumbar transverse processes, it blends with the anterior lamina of the lumbar aponeurosis which covers the quadratus lumborum. Below the level of the iliac crest the iliac fascia covers the iliacus as well as the psoas magnus. This part of it is known as the *fascia iliaca*, and it passes uninterruptedly from the iliacus on to the psoas magnus. *Externally* it is attached to the anterior two-thirds of the iliac crest immediately within its inner lip, and *internally* to the ala of the sacrum and the iliac portion of the ilio-pectineal line. *Inferiorly* it is disposed in the following manner: along the outer half of Poupart's ligament on its deep aspect the fascia is firmly attached to that ligament, and joins the fascia transversalis, the two constructing a canal which contains the first part of the deep circumflex iliac artery. Opposite the external iliac vessels the fascia passes downwards behind them and Poupart's ligament to form the posterior wall of the crural sheath. Internal to the external iliac vessels it is continuous with the pubic lamina of the fascia lata, as that covers the upper part of the pectineus. From the point of junction between the iliac fascia and the pubic fascia lata an intermuscular septum (ilio-pectineal) passes backwards between the pectineus and the psoas magnus to be attached to the ilio-pectineal eminence and the front of the capsular ligament of the hip-joint.

The importance of the iliac fascia has reference to the course taken by pus in cases of lumbar (psoas) abscess. The pus cannot pass outwards over the quadratus lumborum without bursting through the psoas sheath, because the psoas sheath is bound down to the anterior wall of the sheath of the quadratus lumborum at the outer border of the psoas muscle. It cannot pass across the vertebral column on account of the attachments of the psoas sheath in that situation. The usual course, therefore, taken by the pus is to diffuse itself downwards within the psoas sheath. On reaching the iliac fossa it may diffuse itself outwards beneath the iliac fascia as that covers the iliacus muscle, but it cannot enter the pelvic cavity on account of the attachment of the iliac fascia to the pelvic brim, unless it bursts through the psoas sheath. Subsequently the pus usually treks along the psoas magnus

within its sheath, and, passing behind Poupart's ligament and the femoral vessels encased in the crural sheath, it usually points over the saphenous opening on a level with the small trochanter, where it may simulate a femoral hernia.

Lumbar Aponeurosis.—This is situated between the last rib and the iliac crest, and is to be regarded as the posterior aponeurosis of the transversalis abdominis muscle. When followed backwards it divides into three laminæ, anterior, middle, and posterior. The **anterior lamina,** which is thin, covers the quadratus lumborum, and is attached internally to the fronts of the transverse processes of the lumbar vertebræ near their tips. In this situation it is interposed between the quadratus lumborum and psoas magnus, and receives the iliac fascia which forms the psoas sheath. At the outer

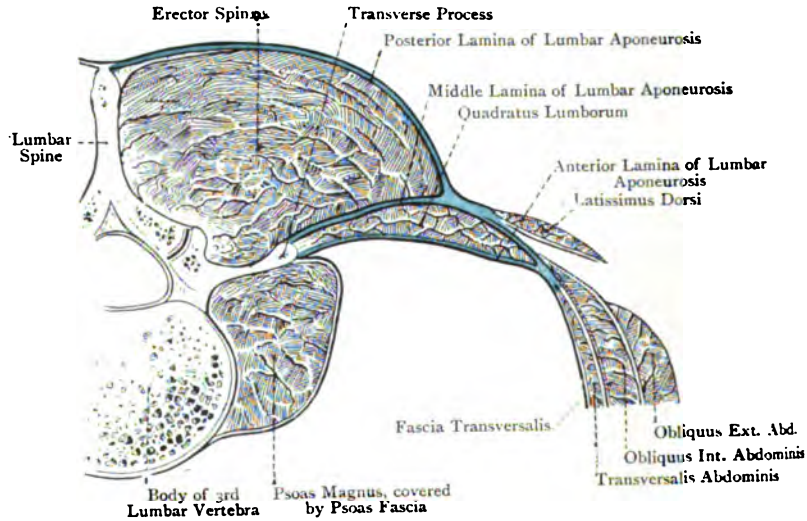


FIG. 320.—DIAGRAM OF THE LUMBAR APONEUROSIS.

border of the quadratus lumborum it joins the middle lamina, and is here also continuous with the fascia transversalis. Superiorly it forms the external arcuate ligament, which extends between the last rib and the tip of the first lumbar transverse process. Inferiorly it is attached to the ilio-lumbar ligament and the contiguous part of the inner lip of the iliac crest. The **middle lamina,** which is of considerable strength, is attached internally to the tips of the lumbar transverse processes, and externally, at the outer border of the quadratus lumborum, it is joined by the anterior lamina, whilst at the outer border of the erector spinæ it receives the posterior lamina. Superiorly it is attached to the lower border of the last rib, and inferiorly to the back part of the summit of the iliac crest. The middle lamina lies between the quadratus lumborum and the

erector spinæ. The **posterior lamina,** which is also very strong, is attached to the spinous processes of the lumbar and sacral vertebræ, and the posterior fourth of the outer lip of the iliac crest. It lies behind the erector spinæ, at the outer border of which it blends with the middle lamina, and so the muscle is enclosed in a sheath. The posterior lamina is joined by the vertebral aponeurosis, and affords attachment to the latissimus dorsi and serratus posticus inferior.

Muscles of the Posterior Abdominal Wall—Psoas Magnus—*Origin.*—(1) The fronts of the transverse processes of the lumbar vertebræ; (2) the lateral aspects of the intervertebral discs, and of the adjacent borders of the twelfth thoracic, and all the lumbar, vertebræ; and (3) a series of fibrous arches which cross the lumbar vessels at the centres of the bodies of the lumbar vertebræ.

Insertion.—The small trochanter of the femur, by a tendon which receives, on its outer side, the greater part of the iliacus.

Nerve-supply.—The lumbar plexus. The branches come more particularly from the anterior primary divisions of the second and third lumbar nerves.

Action.—Acting from its origin the muscle is a powerful flexor of the thigh upon the pelvis, coming into play in walking, or ascending a stair. Acting from its insertion it is a flexor of the lumbar portion of the vertebral column upon the pelvis, and of the pelvis upon the thigh, as in the act of stooping. The muscle of one side, acting from its insertion, is capable of producing lateral flexion of the lumbar portion of the vertebral column.

As the muscle descends close to the pelvic brim the fibres of the iliacus begin to join the outer side of its tendon, and they continue to do so as far as the insertion, thus giving rise to a conjoined muscle known as the **ilio-psoas.**

Psoas Parvus.—This muscle is present in man on one or both sides in about 45 per cent. of bodies. It *arises* from the lateral aspect of the intervertebral disc between the twelfth thoracic and first lumbar vertebræ, and from the contiguous borders of their bodies, by means of a small fleshy belly, which is usually about 2 inches long. It is then replaced by a long, narrow, flat tendon, which expands as it is about to take *insertion* into the middle of the ilio-pectineal line and the ilio-pectineal eminence, in which latter situation it blends with the ilio-pectineal intermuscular septum.

The *nerve-supply* is the anterior primary division of the first lumbar nerve. Acting from its origin the muscle tends to flex the pelvis upon the vertebral column, and is a tensor of the psoas sheath. Acting from its insertion it tends to flex the lumbar portion, and lower part of the thoracic portion, of the vertebral column upon the pelvis. Its characteristic action is seen in the position assumed by saltatory animals preparatory to the act of leaping, that position consisting in a drawing forwards of the pelvis and vertebral column.

The psoas parvus lies along the anterior aspect of the psoas magnus close to its inner border, except at the pelvic brim, where its expanded tendon turns to the inner side of that muscle.

Iliacus—*Origin.*—(1) The upper surface of the ala of the sacrum; (2) the anterior sacro-iliac, ilio-lumbar, and lumbo-sacral ligaments; and (3) the upper half of the iliac fossa, reaching anteriorly as low as the anterior inferior iliac spine.

Insertion.—(1) The outer aspect of the tendon of the psoas magnus; (2) the triangular surface which is situated below, and in front of, the small trochanter of the femur (between it and the spiral line); and (3) the ilio-femoral ligament. The fibres inserted into the ilio-femoral ligament are those which arise in the region of the anterior inferior iliac spine. They are sometimes separated from the rest of the muscle, and are then known as the *iliacus minor* or *ilio-capsularis*.

Nerve-supply.—The anterior crural nerve.

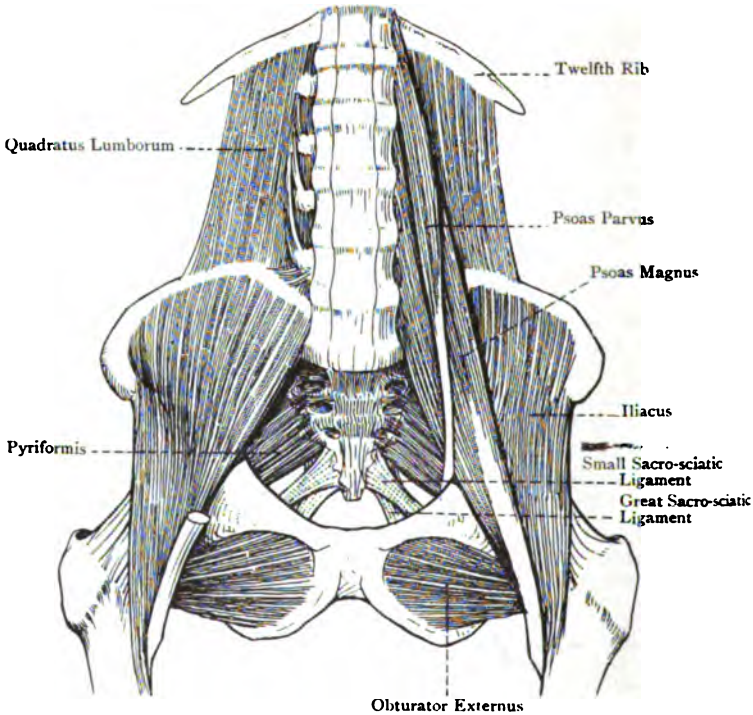


FIG. 321.—THE PSOAS, ILIACUS, AND QUADRATUS LUMBORUM MUSCLES.

Action.—Acting from its origin the muscle is a flexor of the thigh upon the pelvis. Acting from its insertion it is a flexor of the pelvis upon the thigh.

Quadratus Lumborum—*Origin.*—(1) The ilio-lumbar ligament; (2) the inner lip of the crest of the ilium for about 2 inches behind and outside the ilio-lumbar ligament; and (3) the tips of the transverse processes of the lower three or four lumbar vertebræ.

Insertion.—(1) The lower border of the last rib along its inner half, and (2) the tips of the transverse processes of the upper three or

four lumbar vertebræ, by tendinous slips which lie behind the slips of origin.

Nerve-supply.—The subcostal nerve and the anterior primary divisions of the first two lumbar nerves.

Action.—Acting from its origin the muscle depresses and fixes the last rib, and is therefore a muscle of inspiration, inasmuch as it is auxiliary to the diaphragm. In depressing the last rib the muscle is also capable of producing lateral flexion of the vertebral column. Acting from the last rib it will produce lateral flexion of the pelvis.

The muscle is encased in a sheath, the anterior wall of which is formed by the anterior lamina of the lumbar aponeurosis, and the posterior wall by the middle lamina.

Lumbar Plexus.—The lumbar plexus is situated deeply in front of the transverse processes of the first three lumbar vertebræ, where it lies in the psoas magnus. It is formed by the anterior primary divisions of the first three lumbar nerves and the greater part of that of the fourth. In addition, the anterior primary division of the first lumbar is usually reinforced by a small communicating branch from the subcostal nerve, called the *dorso-lumbar nerve.* The nerves concerned in the lumbar plexus first furnish the following branches: (1) the first gives twigs to the psoas parvus when present; (2) the first and second supply branches to the quadratus lumborum; (3) the second and third give branches to the psoas magnus; and (4) the upper two or three furnish white rami communicantes to the lumbar sympathetic gangliated cord. The mode of formation and branches of the plexus are as follows: The first lumbar, having been, as a rule, reinforced by the dorso-lumbar from the subcostal, furnishes, from above downwards, the ilio-hypogastric and inguinal, and then it descends to join a branch from the second. The second, third, and that part of the fourth which enters into the plexus break up into a small anterior or ventral, and a large posterior or dorsal division. The descending branch from the first joins a branch from the ventral division of the second to form the genito-crural nerve, which arises next in order to the inguinal. The external cutaneous nerve arises by two roots from the dorsal divisions of the second and third. The anterior crural nerve arises by three roots from the dorsal divisions of the second, third, and fourth, the root from the third being the largest. The obturator nerve arises usually by three roots from the ventral divisions of the second, third, and fourth, but the root from the second may be absent. The accessory obturator nerve, when present, arises by two roots from the third and fourth, which are interposed between the roots of the anterior crural and main obturator nerves.

The branches of the lumbar plexus are accordingly as follows:

1. Muscular to psoas parvus (when present), from first lumbar.
2. Muscular to quadratus lumborum, from first and second lumbar.

3. Muscular to psoas magnus, from second and third lumbar.
4. Two or three white rami communicantes, to the lumbar sympathetic gangliated cord, from the upper two or three lumbar.
5. Ilio-hypogastric and inguinal, from first lumbar.
6. Genito-crural, from first and *ventral* division of second lumbar.
7. External cutaneous, from *dorsal* divisions of second and third lumbar.
8. Anterior crural, from *dorsal* divisions of second, third, and fourth lumbar.
9. Obturator, from *ventral* divisions of second, third, and fourth lumbar.
10. Accessory obturator (when present), from third and fourth lumbar, between the roots of the anterior crural and main obturator.

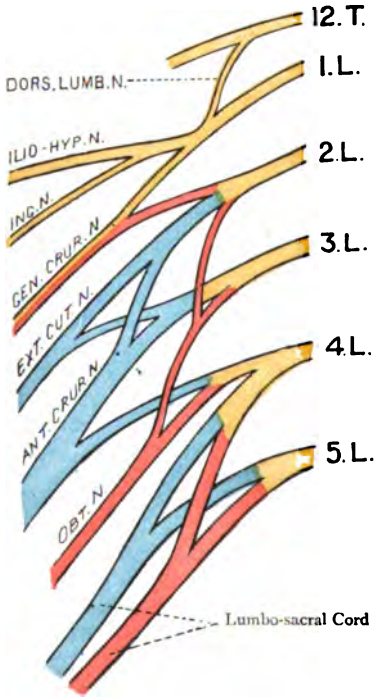


FIG. 322.—DIAGRAM OF THE RIGHT LUMBAR PLEXUS.

The **ilio-hypogastric nerve**, having pierced the outer border of the psoas magnus near its upper part, passes outwards and downwards over the quadratus lumborum, lying below the subcostal nerve and behind the kidney. It then pierces the posterior part of the transversalis abdominis a little above the iliac crest, and furnishes its *iliac* or *lateral cutaneous branch*, which, perforating

the internal and external oblique, crosses the iliac crest at the junction of its middle and anterior thirds to be distributed to the integument of the adjacent part of the gluteal region. The nerve continues its course forwards between the internal oblique and transversalis abdominis, supplying branches to these muscles and communicating with the inguinal nerve. About 1 inch in front of the anterior superior iliac spine it pierces the internal oblique, and then runs forwards between the Poupart fibres of that muscle and the external oblique aponeurosis. Finally it pierces that aponeurosis 1 inch above the external abdominal ring, and is distributed to the integument of the suprapubic region, where it is in series with the anterior cutaneous nerves. The ilio-hypogastric nerve is serially continuous with the intercostal nerves, like which it gives off a lateral cutaneous branch, called iliac, and then ends as an anterior cutaneous nerve.

The inguinal nerve (ilio-inguinal), having pierced the outer border of the psoas magnus lower down than, but close to, the ilio-hypogastric, passes obliquely outwards and downwards over the quadratus lumborum, where it may lie below the lower end of the kidney or behind it. It then passes forwards internal to the inner lip of the iliac crest beneath the transversalis abdominis. In this part of its course it rests upon the iliac fascia and iliacus muscle. Near the anterior part of the iliac crest it pierces the transversalis, and here communicates with the hypogastric branch of the ilio-hypogastric. It subsequently perforates the Poupart fibres of the internal oblique, after which it descends through the lower two-thirds of the inguinal canal, and emerges through the external abdominal ring, where it lies external to the spermatic cord. Finally, having pierced the intercolumnar fascia, it is distributed to the integument of the inner side of the thigh in its upper third, and the integument of the scrotum, or labium majus, according to the sex. The inguinal nerve in its course supplies branches to the internal oblique and transversalis abdominis muscles. It differs from the ilio-hypogastric and intercostal nerves in the following two respects: it does not give off any iliac or lateral cutaneous branch, and it is not distributed to the integument of the abdominal wall.

The **genito-crural nerve** passes forwards through the psoas magnus, and appears on its superficial surface about the level of the body of the third lumbar vertebra, where it lies close to the inner border of the muscle. It sometimes pierces the muscle in two parts, due to an early division of the nerve into its genital and crural branches. It then descends upon the psoas sheath, passing slightly outwards, and crossing behind the ureter. At a variable distance above Poupart's ligament (sometimes in the psoas magnus) the nerve divides into two branches, genital and crural. The *genital branch* lies upon the external iliac artery close above Poupart's ligament, and enters the inguinal canal through the internal abdominal ring to be distributed to the cremaster muscle. The *crural branch* descends on the outer side of the external iliac artery

and passes out behind Poupart's ligament, having, just prior to this, crossed the deep circumflex iliac artery. On entering the thigh it lies for about ½ inch within the crural sheath, and subsequently, piercing the outer wall of that sheath, it is distributed to the integument over Scarpa's triangle.

The **external cutaneous nerve** pierces the outer border of the psoas magnus near its centre, and takes a direction downwards and outwards over the back part of the iliac crest into the iliac fossa. It then crosses the iliacus under cover of the fascia iliaca towards the anterior superior iliac spine, where it emerges on to the thigh behind the outer end of Poupart's ligament. For the distribution of the nerve in the thigh, see p. 424.

The **anterior crural nerve** pierces the outer border of the psoas magnus about the level of the back part of the pelvic brim. It then passes forwards, lying deeply between the psoas magnus and iliacus, and emerges on to the thigh behind Poupart's ligament. Whilst in the abdominal cavity it gives branches to the iliacus muscle. The course and distribution of the nerve in the thigh will be found on p. 443.

The **obturator nerve** pierces the inner border of the psoas magnus at the back part of the pelvic brim, and it lies upon the ala of the sacrum, having the lumbo-sacral cord on its inner side. Passing deeply behind the common iliac artery it enters the pelvic cavity, and passes along the outer wall a little below the pelvic brim, where it lies above the obturator artery. It then emerges on to the thigh through the obturator canal. For the course and distribution of the nerve in the thigh, see p. 447.

The **accessory obturator nerve** (when present) pierces the inner border of the psoas magnus close to the main obturator nerve, but, unlike it, does not enter the pelvic cavity. Its course is forwards along the inner border of the psoas magnus underneath the external iliac vessels, and it emerges on to the thigh by passing over the superior pubic ramus beneath the pectineus muscle. Under cover of that muscle it divides into the following three branches: *articular* to the hip-joint; *muscular* to the deep surface of the pectineus; and a *reinforcing branch* to join the superficial or anterior division of the main obturator nerve.

Varieties of the Lumbar Plexus.—These assume the form of two types, high or prefixed, and low or postfixed. In the *prefixed type* the anterior primary division of the third lumbar is a nervus furcalis, and takes part in the sacral plexus, whilst in the *postfixed type* the anterior primary division of the fifth lumbar is a nervus furcalis, and takes part in the lumbar plexus.

Lumbo-sacral Cord.—This is formed by the union of the ventral and dorsal divisions of the descending branch of the fourth lumbar nerve with the ventral and dorsal divisions of the anterior primary division of the fifth lumbar. It is a large double trunk, which rests upon the ala of the sacrum, being at first under cover of the psoas magnus, and subsequently lying on its inner side, where it has the obturator nerve external to it. In its course it passes behind the common and internal iliac vessels, and in the pelvis, its two divisions having joined those of the anterior primary division of the first sacral nerve, it takes part in the sacral plexus, entering

more particularly the upper or outer band of that plexus which is continued into the great sciatic nerve.

The anterior primary division of the fourth lumbar nerve is known as a *nervus furcalis* from the fact that it is distributed partly to the lumbar and partly to the sacral plexus.

Lumbar Arteries.—These are branches of the abdominal aorta, being parietal in their distribution, and they are serially continuous with the aortic intercostal and subcostal arteries. They are eight in number, four right and four left, and they arise in pairs, separately or conjointly, from the posterior aspect of the parent trunk. They occupy the grooves at the centres of the bodies of the first four lumbar vertebræ. As each artery winds round a vertebral body it passes beneath one of the fibrous arches of the psoas magnus and the lumbar sympathetic gangliated cord. It then passes behind the psoas magnus and lumbar plexus, and, on reaching the interval between two adjacent lumbar transverse processes, it divides into two branches, dorsal and abdominal. The upper two arteries pass beneath the corresponding crus of the diaphragm, and those of the right side also pass beneath the receptaculum chyli and right azygos vein. All four arteries on the right side pass beneath the inferior vena cava. The trunk of each lumbar artery gives off a few vertebral branches to the body and ligaments of the adjacent vertebra, and muscular branches to the psoas magnus. The *dorsal branch* passes backwards between the adjacent transverse processes, in company with the posterior primary division of a spinal nerve, and it divides into an internal and external branch. The internal branch supplies the multifidus spinæ, and the external branch supplies the erector spinæ, giving also cutaneous branches which accompany the cutaneous nerves to the integument. Opposite an intervertebral foramen the dorsal branch furnishes a *spinal branch*, which enters the spinal canal through the foramen, to be distributed to the spinal cord and its coverings, as well as to the wall of the canal.

The *abdominal branch* is to be regarded as the continuation of a lumbar artery. These branches usually pass behind the quadratus lumborum, with the exception, as a rule, of that of the fourth. At the outer border of that muscle they pierce the posterior aponeurosis of the transversalis abdominis, and pass forwards between that muscle and the internal oblique, as far as the lower part of the rectus abdominis, which they enter. They furnish the following offsets, in order: muscular to the quadratus lumborum; capsular to the capsule of the kidney, which anastomose with branches of the renal artery; subperitoneal to the subperitoneal areolar tissue, which anastomose therein with branches of the ilio-lumbar, the inferior phrenic, and the hepatic, colic, and renal arteries, thus forming the subperitoneal arterial plexus of Turner; muscular to the abdominal muscles, which anastomose above with the lower two intercostal and subcostal arteries, below with the lateral or intermuscular epigastric of the deep circumflex iliac, and ilio-lumbar,

and in front with the deep epigastric. Sometimes there are five lumbar arteries on each side, the fifth pair coming usually from the middle sacral artery. Each of these passes beneath the corresponding common iliac vessels, and, having furnished a dorsal branch, usually to the gluteus maximus, it is distributed over the lateral mass of the sacrum and ends in the iliacus, where it anastomoses with the deep circumflex iliac artery.

The **lumbar veins** open into the inferior vena cava, those of the left side passing behind the abdominal aorta. The vessels of each side are connected by a series of longitudinal anastomosing veins in front of the lumbar transverse processes, and the longitudinal vessel thus formed is called the *ascending lumbar vein*.

Subcostal Artery.—This vessel is the last parietal branch of the thoracic aorta. It lies below the last rib, and is in series with the aortic intercostals above and the lumbar arteries below. It winds round the side of the body of the twelfth thoracic vertebra, and courses along the lower border of the twelfth rib with the subcostal nerve, passing behind the external arcuate ligament of the diaphragm and in front of the quadratus lumborum. This part of the vessel is behind the kidney and the ascending or descending colon, according to the side. Its subsequent course corresponds with that of the abdominal branches of the lumbar arteries. It anastomoses with the lower two intercostal arteries, the abdominal branches of the lumbar arteries, the lateral or intermuscular epigastric of the deep circumflex iliac, and the deep epigastric artery. This vessel has to be borne in mind in such operations as nephrotomy, nephrorrhaphy, and nephrectomy.

The **subcostal vein** of each side enters the thorax behind the external arcuate ligament of the diaphragm, the right opening into the right azygos vein, and the left into the lower left azygos vein.

Subcostal Nerve.—This is the anterior primary division of the twelfth thoracic nerve, and is in series with the eleventh or last intercostal. It accompanies the subcostal artery, and ultimately enters the sheath of the rectus abdominis, which muscle it pierces from behind forwards to become an anterior cutaneous nerve. In its course it gives off an undivided *lateral cutaneous* or *iliac branch*, which pierces the internal and external oblique muscles, and descends over the iliac crest to be distributed to the integument of the anterior part of the gluteal region. Besides this branch it furnishes the following offsets: (1) *dorso-lumbar* to the anterior primary division of the first lumbar nerve; and (2) branches to the quadratus lumborum, transversalis abdominis, internal oblique, and pyramidalis abdominis.

Lumbar Glands.—These are very numerous, and are divided into three groups—median, and two lateral, right and left.

The **median lumbar,** or **aortic, glands** are about twelve in number, and lie behind the parietal peritoneum, in front of, behind, and along the sides of the aorta (as high as the root of the superior mesenteric artery) and inferior vena cava. A few of the lower glands lie along

the common iliac arteries, and these are sometimes spoken of as the **common iliac glands.** The median lumbar glands receive their afferent vessels from the following sources: (1) the external iliac glands; (2) the internal iliac glands; (3) the sacral glands; (4) the efferent lymphatics of the testes in the male, and of the ovaries, Fallopian tubes, and upper end of the uterus in the female; (5) the kidneys; (6) the suprarenal capsules; (7) the vertebral part of the diaphragm; and (8) some of the efferent vessels of the lateral lumbar glands. Their efferent vessels unite to form two **lumbar lymphatic trunks,** right and left, which open into the lower end of

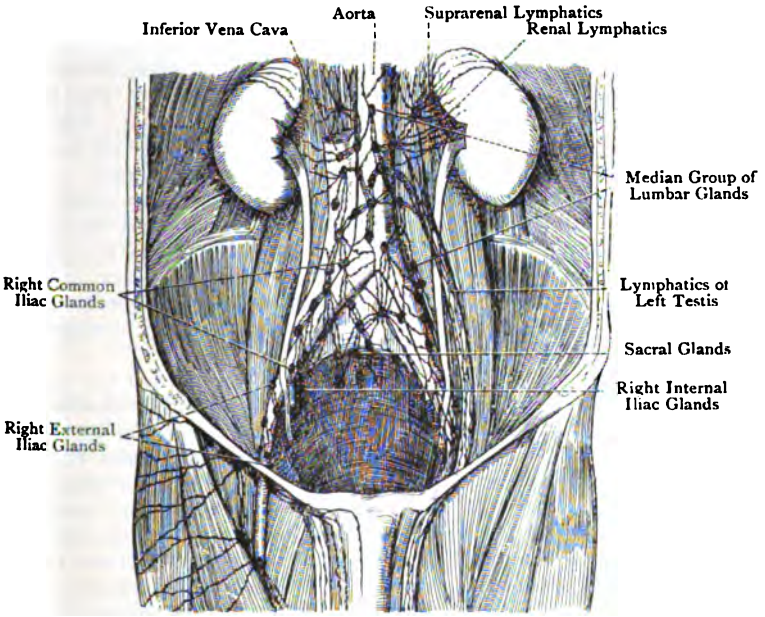


FIG. 323.—LYMPHATICS OF THE ABDOMEN (AFTER MASCAGNI).

the receptaculum chyli on a level with the body of the second lumbar vertebra. The left trunk receives the lymphatics of the lower part of the left colon, iliac colon, and pelvic colon.

The **lateral lumbar glands** are small but very numerous, being about twenty in number. They are situated behind the psoas magnus, where they lie between the lumbar transverse processes, and they receive their afferent vessels from the following sources: (1) the posterior abdominal wall and deep muscles of the back, and (2) the spinal canal. Some of their efferent vessels join the right and left lumbar lymphatic trunks, whilst others open independently into the lower end of the receptaculum chyli.

Common Iliac Arteries.—These vessels are the terminal

branches of the abdominal aorta. They arise from that vessel opposite the centre of the body of the fourth lumbar vertebra, a finger's breadth to the left of the middle line, and they at once diverge from each other. Their course is obliquely downwards and outwards over the lower portion of the body of the fourth and the whole of that of the fifth lumbar vertebra, as well as the disc between the two. Each artery, on arriving opposite the lumbo-sacral articulation, ends by dividing into external and internal iliac arteries. The length of the right common iliac is about 2 inches, and that of the left about 1¾ inches. The left vessel is less oblique in direction than the right, and the course of each may be indicated in the following manner: draw a line from a point fully 1 inch below the umbilicus, a finger's breadth to the left of the middle line, to a point at the groin midway between the anterior superior iliac spine and the symphysis pubis, and let this line be slightly curved with the convexity directed outwards. About the upper 2 inches of this line indicate the course of the common iliac artery, and the remainder that of the external iliac vessel.

Relations—*Anterior.*—The peritoneum, coils of the small intestine, one half of the aortic sympathetic plexus, and the ureter, which latter crosses the artery close to its termination, though it may be transferred to the commencement of the external iliac vessel. An additional superficial relation of the left common iliac artery is that it is crossed by the superior hemorrhoidal vessels.

Posterior.—Each artery rests upon the lower half of the body of the fourth and the whole of that of the fifth lumbar vertebra, as well as the disc above and below the latter, and the gangliated sympathetic cord. The **right** vessel is separated from the foregoing structures by the commencement of the inferior vena cava, the terminal part of the left common iliac vein, and the right common iliac vein, whilst the **left** vessel is free from posterior venous relations. Lying deeply behind each artery there are the obturator nerve, lumbo-sacral cord, and ilio-lumbar artery.

External.—On the outer side of the **right** vessel there are, from above downwards, the inferior vena cava, right common iliac vein, and psoas magnus. On the outer side of the **left** vessel is the psoas magnus.

Internal.—On the inner side of the **right** vessel, from below upwards, there are the right common iliac vein, the left common iliac vein, and the hypogastric sympathetic plexus. On the inner side of the **left** vessel there are the left common iliac vein, and the hypogastric plexus.

It is to be noted that the left artery is related only to its own vein, which lies on its inner side. The right artery, on the other hand, is related to three veins as follows: the inferior vena cava, which lies partly behind its upper end and partly on its outer side; the terminal part of the left common iliac vein, which lies partly on its inner side and partly behind it; and the right common iliac

vein, which, from below upwards, lies first on its inner side, then behind it, and finally on its outer side.

Branches.—These are as follows: peritoneal to the peritoneum and subperitoneal areolar tissue; muscular to the psoas magnus; ureteric to the ureter (all of small size and unimportant); external iliac; and internal iliac. In some cases the common iliac gives off one or other of the following vessels: ilio-lumbar, middle sacral, lateral sacral, lumbar, or an aberrant renal artery.

Varieties.—The chief variety affects the length of the vessel. It may be very short, which is due either to a low bifurcation of the aorta or a high bifurcation of the artery itself; or it may be very long, which is due to exactly opposite causes. When abnormally long, the vessel is usually more or less tortuous.

Collateral Circulation.—After ligature of a common iliac artery, the chief channels by which the circulation is carried on are as follows: (1) the superior epigastric of the internal mammary from the first part of the subclavian anastomoses with the deep epigastric of the external iliac; (2) the lumbar branches of the aorta anastomose with (*a*) the lateral or intermuscular epigastric of the deep circumflex iliac from the external iliac, and (*b*) the ilio-lumbar of the internal iliac; (3) the superior hemorrhoidal of the inferior mesenteric from the aorta anastomoses with (*a*) the middle hemorrhoidal of the internal iliac, and (*b*) the inferior hemorrhoidal of the internal pudic from the internal iliac; (4) the middle sacral from the aorta anastomoses with the lateral sacral branches of the internal iliac; and (5) the pubic branches of the obturator from the internal iliac and of the deep epigastric from the external iliac, both of one side, anastomose across the middle line with the corresponding branches of the opposite side. The vesical, and middle and inferior hemorrhoidal arteries of one side anastomose in a similar manner with those of the opposite side.

Common Iliac Veins.—Each vein is formed by the union of the external and internal iliac veins opposite the corresponding sacro-iliac articulation, on a level with the brim of the pelvis. They unite to form the inferior vena cava opposite the upper border of the body of the fifth lumbar vertebra a little to the right of the middle line, behind and on the right side of the right common iliac artery. The right vein is necessarily shorter than the left, and it ascends almost vertically, lying at first internal to, then behind, and finally on the outer side of its own artery. The left vein ascends very obliquely from left to right, lying internal to its own artery, and then behind that of the right side. It crosses the middle sacral artery, and is crossed by the superior hemorrhoidal vessels and the left half of the aortic plexus. The common iliac veins are usually destitute of valves.

Tributaries.—These are chiefly the external iliac, internal iliac, and ilio-lumbar. In addition, the left vein receives the middle sacral vein.

The *left* common iliac vein is mainly the persistent and enlarged *transverse branch* (transverse iliac) which connects the right and left cardinal veins of the embryo above the back part of the pelvic brim. Its commencement, however, is developed from a portion of the left cardinal vein. The *right* common iliac vein is developed from the part of the right cardinal vein which intervenes between the termination of the right external iliac vein and the right extremity of the transverse iliac vein.

External Iliac Artery.—This vessel is the larger of the two terminal divisions of the common iliac in the adult. It extends from the lumbo-sacral articulation to the lower margin of Poupart's ligament, where it is continued into the common femoral artery. Its course is along the pelvic brim, and at the groin it passes through the vascular lacuna at a point midway between the anterior superior iliac spine and the symphysis pubis. The line indicating the course of the vessel corresponds to the lower part of that which has been given as indicating the course of the common iliac. The vessel is from 3½ to 4 inches long, and its direction is downwards, outwards, and forwards.

Relations—*Anterior.*—The artery is covered by the parietal peritoneum and subperitoneal areolar tissue, the portion of the latter which is related to it being known as **Abernethy's fascia.** The right vessel at its commencement is crossed by the terminal part of the ileum, and sometimes by the vermiform appendix, whilst the left at its commencement is crossed by the pelvic colon, and each may be crossed by the ureter. In the female both arteries are crossed superiorly by the ovarian vessels. Near Poupart's ligament each vessel is crossed by the deep circumflex iliac vein, and the genital branch of the genito-crural nerve lies upon it. The spermatic vessels in the male also lie for a short distance upon it in this situation, and the vas deferens (or round ligament of the uterus) arches over it from without inwards. The external iliac glands lie along the artery. *Posterior.*—The artery rests upon the iliac fascia at the pelvic brim, except for a little above Poupart's ligament, where it lies upon the psoas muscle with the intervention of the iliac fascia, as that forms its sheath. The right artery at its commencement has its own vein behind it for a short distance, and each vessel may have the accessory obturator nerve as a deep posterior relation. *External.*—The psoas magnus covered by the iliac fascia, the genito-crural nerve, and its crural branch. *Internal.*—The peritoneum, the subperitoneal areolar tissue (Abernethy's fascia), which binds the artery with its vein to the iliac fascia, the external iliac vein (except for a short distance above on the right side, where the vein is behind its artery), and the vas deferens near Poupart's ligament.

Branches.—These are as follows : muscular to the psoas magnus ; glandular to the external iliac glands (both unimportant) ; deep epigastric ; and deep circumflex iliac. For the latter two, see pp. 623, 624.

Varieties of the Branches.—(1) The origin of the deep epigastric may be transferred to the common femoral, or to the arteria profunda femoris, and the deep circumflex iliac may be transferred to the common femoral. (2) The internal circumflex, obturator, or arteria profunda femoris may arise from the external iliac, in which latter case two large arteries would emerge on to the thigh beneath Poupart's ligament.

The **external iliac vein** is the continuation of the femoral vein. It extends from the lower border of Poupart's ligament to

the sacro-iliac articulation on a level with the brim of the pelvis, where it joins the internal iliac, and so forms the common iliac vein. There are usually two valves within it. Its chief tributaries are the deep epigastric and deep circumflex iliac veins, both joining it just above Poupart's ligament.

The external iliac vein of adult life is preceded in function by the sciatic vein of the embryo, which is the primitive vein of the lower limb. In the process of development the upper part of the femoral and the whole of the external iliac vein of the adult are continued upwards from the long saphenous vein to the cardinal portion of each common iliac vein, and the sciatic vein is now a tributary of the internal iliac.

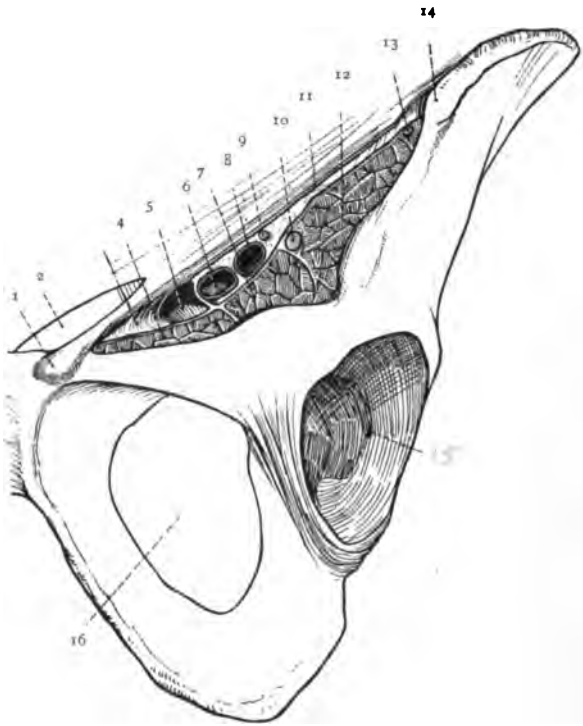
Collateral Circulation.—When the external iliac artery is ligatured, the collateral circulation is carried on through the following channels: (1) the superior epigastric of the internal mammary from the first part of the subclavian anastomoses with the deep epigastric of the external iliac; (2) the pubic branch of the obturator from the internal iliac anastomoses with the pubic branch of the deep epigastric; (3) the ilio-lumbar and gluteal, both from the internal iliac, and the abdominal branches of the lumbar arteries from the aorta anastomose with the deep circumflex iliac of the external iliac; (4) the obturator from the internal iliac anastomoses with the internal circumflex of the arteria profunda femoris; (5) the sciatic from the internal iliac anastomoses with the internal and external circumflex, and the first perforating of the arteria profunda femoris; (6) the gluteal anastomoses with the external circumflex and the ascending branch of the internal circumflex from the arteria profunda femoris; (7) the arteria comes nervi ischiadici of the sciatic anastomoses with the perforating branches of the arteria profunda femoris; and (8) the superficial perineal and dorsalis penis of the internal pudic from the internal iliac anastomose with the superior and inferior external pudics of the common femoral.

External Iliac Glands.—These are about nine in number, and they lie along the course of the external iliac artery. Three of them are usually related to the vessel just above Poupart's ligament, one being on its inner side, one upon it, and one external to it. They receive their afferent vessels from the following sources: (1) the deep femoral glands, (2) some of the efferent vessels of the inguinal and superficial femoral or saphenous glands, (3) the lymphatics from the regions supplied by the deep epigastric and deep circumflex iliac arteries, and (4) some of the lymphatics of the bladder. Their efferent vessels pass to the median lumbar glands, through the intervention of the so-called common iliac glands.

Lacunar Region.—The lacunar region is situated between Poupart's ligament and the anterior margin of the os innominatum, and is divided into two compartments—muscular and vascular.

The **muscular lacuna** is subdivided into two portions, external or iliac, and internal or pectineal, by the *ilio-pectineal septum*, which separates the psoas magnus from the pectineus. This septum passes between the ilio-pectineal eminence and the fascia iliaca at its point of junction with the upper part of the pubic portion of the fascia lata. The *iliac compartment*, which is of large size, is bounded in front by the outer part of Poupart's ligament and the iliac fascia, behind by the anterior margin of the ilium, and

internally by the ilio-pectineal septum. It transmits (1) the ilio-psoas muscle, (2) the external cutaneous nerve, and (3) the anterior crural nerve. The *pectineal compartment* is situated between the superior pubic ramus behind, and the upper part of the pubic lamina of the fascia lata in front, the ilio-pectineal septum being external to it. It contains the origin of the pectineus muscle, and



1. Pubic Spine
2. External Abdominal Ring
3. Gimbernat's Ligament
4. Pectineus
5. Crural or Femoral Ring
6. Femoral Vein
7. Psoas Magnus
8. Femoral Artery
9. Crural Branch of Genito-crural Nerve
10. Anterior Crural Nerve
11. Poupart's Ligament
12. Iliacus
13. External Cutaneous Nerve
14. Ant. Superior Iliac Spine
15. Acetabulum
16. Obturator Foramen

FIG. 324.—POUPART'S LIGAMENT AND THE LACUNAR REGION.

is shut off from the abdominal cavity by the attachment of the pubic lamina of the fascia lata to the pectineal portion of the ilio-pectineal line. In connection with this portion of the fascia lata there is a bundle of fibres, known as the *pubic ligament of Cooper*. This ligament extends between the ilio-pectineal eminence and the pubic spine, between which points it is attached to the pectineal portion of the ilio-pectineal line in front of Gimbernat's ligament, being closely incorporated with the pubic lamina of the fascia lata.

The **vascular lacuna** is situated anterior to the other two. It is bounded posteriorly by the connection between the iliac fascia and the pubic lamina of the fascia lata, whilst anteriorly it is bounded by the central portion of Poupart's ligament and the downward prolongation of the fascia transversalis to form the anterior wall of the crural sheath, that fascia being here strengthened by the deep crural arch. It gives passage to (1) the external iliac vessels, the vein being internal to the artery, and (2) the crural branch of the genito-crural nerve, which lies close to the outer side of the artery. The part of this lacuna internal to the external iliac vein forms the crural or femoral ring, which is closed by the septum crurale.

STRUCTURE AND DEVELOPMENT OF THE ABDOMINAL VISCERA

Structure of the Stomach.

The wall of the stomach is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, which covers every part of the organ except (1) along the great and small curvatures, and (2) the *uncovered trigone*, situated on the posterior surface, below and a little to the left of the cardiac orifice.

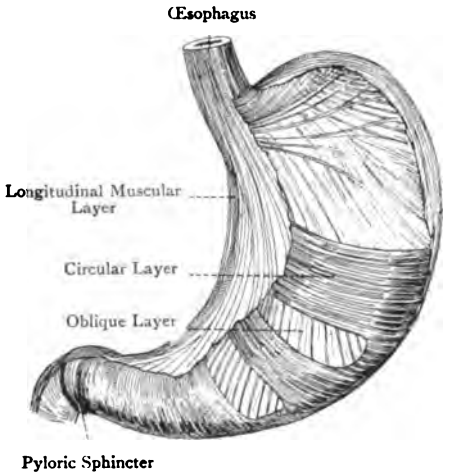


FIG. 325.—DISSECTION SHOWING THE MUSCULAR LAYERS OF THE STOMACH.

The **muscular coat** (*muscularis externa*) is composed of plain muscular tissue disposed in three layers—external or longitudinal, middle or circular, and internal or oblique. The *external* or *longitudinal fibres* are continuous with the longitudinal fibres of the œsophagus, and at the pyloric end of the stomach they are continuous with the longitudinal fibres of the duodenum. They are most abundant along the small curvature. The *middle* or *circular fibres* are continuous with the more superficial circular fibres of the lower end of the œsophagus. They commence on the right side of the cardiac orifice as a series of U-shaped bundles, which loop over the small curvature at the right of the cardia, and pass downwards and to the left on both surfaces

(Birmingham). When traced towards the right, these looped fibres gradually become circular, and form a complete investment to the stomach. At the pylorus they become augmented, and are gathered together into a thick muscular ring, called the **sphincter pylori,** the outermost fibres of which become continuous with the circular fibres of the duodenum. The *internal* or *oblique fibres* are continuous with the deeper circular fibres of the lower end of the œsophagus. They commence as U-shaped bundles, which loop over the stomach immediately to the left of the cardia, and run very obliquely downwards and to the right for a considerable distance on both surfaces of the organ. These looped fibres, on being traced towards

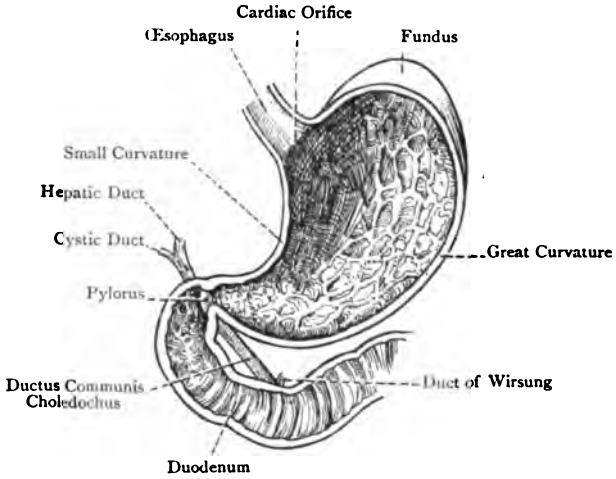


FIG. 326.—THE STOMACH AND DUODENUM OPENED.

the left, gradually become less oblique, and finally form circles which surround the wide end of the stomach completely, even as far as the summit of the fundus (Birmingham). The internal or oblique fibres embrace the cardiac orifice, round which they are disposed somewhat after the manner of a sphincter muscle. They cannot be traced as far as the pylorus, but end by inclining downwards to the great curvature, where they blend with the circular fibres.

The **submucous coat** is situated between the muscular and mucous coats. It is composed of loose areolar tissue, and serves partly as a connecting medium, and partly as a bed in which the arteries subdivide before entering the mucous coat.

The **mucous coat** is covered by a single layer of columnar epithelium, many of the cells being mucus-secreting goblet cells. It is soft and pulpy, and in the empty state of the viscus is thrown into rugæ, which are for the most part longitudinal, and are due to the loose connection between the muscular and mucous coats. These, however, are readily effaced when the stomach becomes distended.

It is thickest towards the pyloric end, and in healthy adults it has a light crimson colour, while in early life this is heightened into a bright rosy tint. After death, however, it presents a mottled appearance, being marked with grey-brown patches. When examined with a lens, it presents a great number of polygonal depressions, varying in diameter from $\frac{1}{100}$ to $\frac{1}{350}$ inch, the largest being near the pylorus. These impart to it a honeycomb appearance. The mucous membrane surrounding them is elevated into ridges by subjacent capillary networks, and in the region of the pylorus these ridges present processes, called *plicæ villosæ*. The polygonal depressions are beset with minute pores, which are the orifices of the **gastric glands.** These glands, which belong to the tubular variety, are placed perpendicularly in the mucous coat, and are closely packed together like upright stakes. They are of two kinds, cardiac and pyloric, between which there are certain differences.

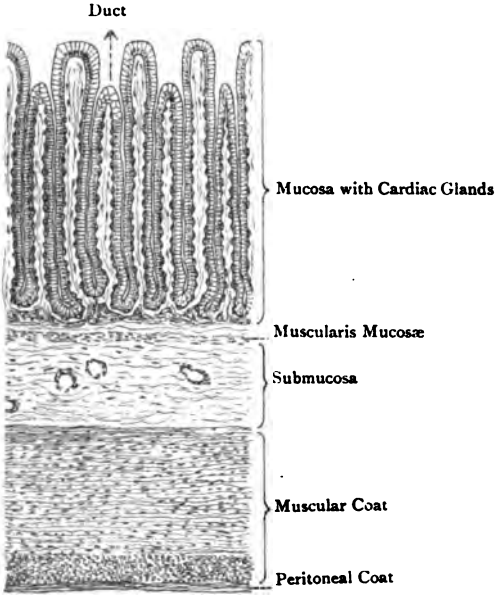


FIG. 327.—THE CARDIAC GLANDS OF THE STOMACH (HIGHLY MAGNIFIED).

The **cardiac glands** are situated in the cardiac two-thirds. The **duct** of each forms about one-third of the entire length of the gland. It is lined with a single layer of columnar epithelium. The deep end of the duct is connected with two or three *gland-tubes*, which represent two-thirds of the entire gland. Each gland-tube is divisible into a neck, body, and fundus. The *neck* is the part connected with the duct, and it forms one-third of the length of the gland-tube. It is narrower than the body, and is lined with coarsely granular polyhedral cells, which almost completely fill it, thus leaving a very small lumen. These are called the **central** or **chief cells.** Between these and the basement membrane there are interposed large oval or spherical granular cells, each having a clear nucleus. These, which are called the **parietal** or **oxyntic** ('acid-forming') **cells,** do not form a continuous layer, but are placed at intervals, and they give rise to small swellings on the wall of the neck. The *body* is wider than the neck, and forms two-thirds of

the length of the gland-tube. It is lined by a prolongation of the central or chief cells of the neck, which almost completely fill it, and which have now become somewhat columnar and transparent. Between these cells and the basement membrane there are a few parietal or oxyntic cells here and there. The parietal cells of the neck and body impart the characteristic beaded appearance to the gland-tube. The *fundus* is the blind deep end of the gland-tube.

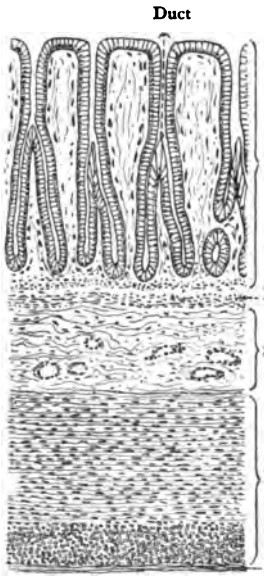


FIG. 328. — THE PYLORIC GLANDS OF THE STOMACH (HIGHLY MAGNIFIED).

The **pyloric glands** are situated in the pyloric third. The duct of each forms one half of the entire length of the gland. It is lined with a single layer of columnar epithelium. The deep end of the duct is connected with two or three gland-tubes, which represent one half of the entire gland. The neck of each tube is comparatively short, and the body is branched at its deep extremity. The neck and body are lined with cubical granular cells, representing the central or chief cells of the cardiac glands, and they are not so crowded as in the cardiac glands, so that there is a very distinct lumen. There is an entire absence of parietal or oxyntic cells, and the body of each gland-tube has an undulating, convoluted outline. The pyloric glands are serially continuous with Brunner's glands of the small intestine.

Summary of the Cardiac and Pyloric Glands.

Cardiac Glands.

1. Ducts short.
2. Gland-tubes long.
3. Gland-tubes almost filled with coarsely granular polyhedral cells, called central or chief cells.
4. Lumen very small.
5. Gland-tubes have parietal or oxyntic cells between the central cells and the basement membrane.

Pyloric Glands.

1. Ducts long.
2. Gland-tubes short.
3. Gland-tubes lined with cubical granular cells.
4. Lumen distinct.
5. Gland-tubes destitute of parietal or oxyntic cells.

At the deepest part of the mucous coat, and forming a part of it, there is a stratum of plain muscular tissue, called the *muscularis mucosæ* (*muscularis interna*), which is disposed in two layers—outer longitudinal, and inner circular. The mucous membrane is also provided with lymphoid tissue in the interspaces between the deep ends of the gastric glands. In the cardiac part of the stomach this lymphoid tissue occurs in the form of isolated collections, called **lymph follicles,** which bear a resemblance to the solitary glands of the intestinal mucous membrane. In the neighbourhood of the pylorus these lymph follicles become aggregated, and so resemble somewhat the agminated glands or Peyer's patches of the small intestine.

Blood-supply—Arteries.—Along the small curvature there are (1) the gastric branch of the cœliac axis in two divisions, and (2) the pyloric branch of the hepatic, also in two divisions. Along the great curvature there are (1) the right gastro-epiploic of the gastro-duodenal of the hepatic from the cœliac axis, and (2) the left gastro-epiploic of the splenic from the cœliac axis. At the fundus there are the vasa brevia of the splenic artery.

The branches arising from all these arteries enter the muscular coat without piercing the peritoneum. They subsequently make their way inwards to the submucous coat, where they break up into branches which freely anastomose with one another. Fine branches then enter the mucous coat, which run upwards between the closely-packed gastric glands, round which they form by their anastomoses a delicate capillary network with its meshes elongated in the direction of the gland-tubes. From this network somewhat larger vessels proceed upwards, which by their anastomoses form a coarser and more superficial network around the orifices of the ducts of the glands.

Veins.—These arise from the superficial network of capillaries round the orifices of the ducts of the glands. They take a downward course between the gland-tubes, and on reaching their deep ends they form a plexus. From this plexus branches proceed outwards to the submucous coat, in which they form another plexus. The branches arising from this latter plexus, having passed through the muscular coat, terminate in the following veins: (1) the right gastro-epiploic, which opens into the superior mesenteric; (2) the left gastro-epiploic and vasa brevia, which open into the splenic; (3) the gastric; and (4) the pyloric, the latter two opening directly into the vena portæ. The veins of the stomach contain numerous valves, which are sufficiently competent in early life to oppose the return of venous blood, but in the adult they are incompetent.

Lymphatics.—These commence near the free surface of the mucous membrane either in loops or in enlargements, and they take a downward course between the gland-tubes, where they open into a network of lacunar spaces. The branches which proceed from this network on reaching the deep ends of the glands form a plexus,

and the vessels issuing from this plexus on entering the submucous coat form another plexus, the lymphatics of which are furnished with valves. The vessels which emerge from this latter plexus accompany the bloodvessels, and pass to the small and great curvatures, and the vicinity of the hilum of the spleen. At the curvatures they are connected with the superior and inferior gastric lymphatic glands, whilst those which accompany the vasa brevia arteries pass through the splenic glands, the efferent vessels of all these glands ultimately passing to the cœliac glands. In addition to the lymphatic vessels just described there is a subperitoneal lymphatic plexus.

Lymphatic Glands.—These form two groups—superior and inferior. The *superior glands* are about six in number, and are situated along the small curvature. They receive as afferent vessels the superior gastric lymphatics, and their efferent vessels pass to the cœliac glands. The *inferior glands* are about eight in number, and are situated along the great curvature. They receive as afferent vessels the inferior gastric lymphatics, and those of the gastro-colic omentum, and their efferent vessels pass to the cœliac glands.

Nerves.—These are derived from (1) the two pneumogastric nerves, and (2) sympathetic plexuses from the solar plexus. The **right** pneumogastric nerve descends upon the *posterior surface* of the stomach, whilst the **left** nerve descends upon the *anterior surface*. The sympathetic plexuses closely accompany the arteries. The nerves form two gangliated plexuses composed of non-medullated nerve-fibres. One of these is situated between the longitudinal and circular fibres of the external muscular coat, and corresponds to the plexus myentericus of Auerbach of the intestine. The other plexus is situated in the submucous coat, and corresponds to the plexus of Meissner of the intestine.

The explanation of the right pneumogastric nerve descending upon the posterior surface, and the left upon the anterior surface, of the stomach is found in the position assumed by the stomach in the early embryo. Briefly stated, at that period of life the stomach is a straight tube, and its surfaces are right and left. The two pneumogastric nerves, therefore, right and left, naturally descend on the right and left surfaces of the viscus. When, however, the stomach turns over on its right side, the surface which was originally right becomes posterior, and the surface which was originally left becomes anterior. Thus the right nerve eventually descends on the posterior (originally the right) surface, and the left nerve descends on the anterior (originally the left) surface.

Pylorus.—The opening between the pyloric end of the stomach and the duodenum is provided with a sphincter muscle, called the *sphincter pylori*. This is formed by an aggregation of the *circular* muscular fibres, and it causes the mucous membrane to project in the form of an annular fold, which is called the **pyloric valve,** or **pylorus.** The sphincter pylori is only relaxed when the contents of the stomach are being passed into the duodenum. At all other times it is in a condition of firm contraction, and the pyloric orifice then takes the form of a cleft.

The average length of the stomach is about 12 inches, and its average width at the widest part about 5 inches. It weighs about 4½ ounces, and its capacity, which is very variable, ranges from 3 to 5 pints.

Structure of the Intestinal Canal.

Small Intestine.—The wall of the small intestine, which is cylindrical, is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** is formed by peritoneum derived from the mesentery proper. In the case of the duodenum it is incomplete, but it forms a complete investment to the jejunum and ileum, except along a narrow interval corresponding to the mesenteric border of the bowel, where the peritoneal investment becomes continuous with the two layers of the mesentery proper.

The **muscular coat** (*muscularis externa*) is composed of plain muscular tissue, disposed in two layers, external or longitudinal, and internal or circular. The *external* or *longitudinal fibres* are continuous with the corresponding fibres of the stomach, and they are best marked along the anti-mesenteric border. The *internal* or *circular fibres* are continuous with the outermost fibres of the sphincter pylori, and form a much thicker layer than the longitudinal. The muscular coat attains its greatest thickness in the duodenum, whence it gradually diminishes. Between the two muscular layers there is a gangliated plexus of non-medullated nerve-fibres, called the **plexus myentericus of Auerbach,** and also a plexus of lymphatic vessels.

The **submucous coat** is situated between the muscular and mucous coats. It is composed of loose areolar tissue, and serves partly as a connecting medium and partly as a bed in which the arteries subdivide. It contains a gangliated plexus of non-medullated nerve-fibres, called the **plexus of Meissner,** and a plexus of lymphatic vessels. In the duodenum this coat lodges Brunner's glands, and the deep ends of the solitary glands project into it throughout.

The **mucous coat** is red and thick in the upper part of the small intestine, but pale and thin in the lower part. It is covered by a single layer of columnar epithelium, many of the cells being mucus-secreting goblet cells. The protoplasm of the cells is longitudinally fibrillated, and their free ends are covered by a delicate *striated basilar border*, the striations being vertically disposed. Underneath the epithelium there is a basement membrane, known as the *subepithelial endothelium*, and underneath this is the main part of the mucous coat, which is essentially composed of adenoid tissue, that is to say, retiform tissue containing in its meshes lymph corpuscles. At the deepest part of the mucous coat, and forming a part of it, there is a stratum of plain muscular tissue, called the *muscularis mucosæ* (*muscularis interna*), which in many situations is disposed in two layers—outer longitudinal, and inner circular.

In some places, however, only the outer longitudinal layer is present. The mucous coat is beset all over with minute projections, called villi, and is sometimes called the **villous coat.** These villi impart to it a woolly appearance like the nap of velvet. It diminishes in thickness from above downwards, and is characterized by the following structures: (1) valvulæ conniventes, (2) villi, (3) Brunner's glands, (4) crypts or follicles of Lieberkühn, (5) solitary glands, and (6) agminated glands or Peyer's patches.

Of the foregoing structures the valvulæ conniventes, villi, and Peyer's patches constitute the *macroscopical* (naked-eye) characters of the mucous membrane, the others forming its *microscopical* characters.

The **valvulæ conniventes** (valves of Kerkring) are permanent folds of the mucous membrane, which cannot be effaced. They are absent from the first part of the duodenum for a distance of from 1 to 2 inches from the pylorus. Commencing about the upper end of the second part of the duodenum as small straggling folds, they become large and distinct at the place of entrance of the ductus communis choledochus and pancreatic duct (about 4 inches from the pylorus). Throughout the rest of the duodenum and in the upper part of the jejunum they are still prominent, and are placed close to each other. In the lower part of the jejunum they become smaller, and are placed farther apart. In the upper part of the ileum they become still smaller and more irregular, and they finally disappear just beyond the centre of the ileum. They are crescentic folds placed across the bowel, and each consists of two layers of mucous membrane applied back to back, with a little submucous areolar tissue intervening. Their average length is about 2½ inches, and the average breadth of each is about ⅓ inch. The majority of them extend round the bowel for from one-half to two-thirds of its circumference. Some, however, describe complete circles, whilst a few are arranged in a spiral manner so as to describe from one to three turns round the tube. Some of them begin and terminate in bifurcated extremities, whilst others present abrupt single extremities. The purpose served by the valvulæ conniventes is a twofold one. In the first place they increase the extent of the absorbing and secreting surface of the mucous membrane, and in the second place they delay the passage of the intestinal contents, and so afford time for digestion and absorption.

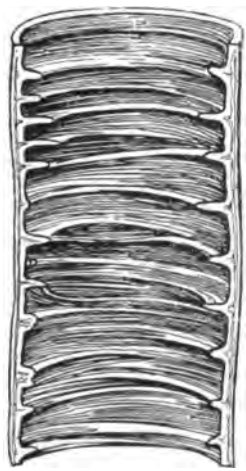


FIG. 329.—THE VALVULÆ CONNIVENTES.

In connection with the valvulæ conniventes of the duodenum the common orifice of the ductus communis choledochus and

pancreatic duct has to be noted. At the junction of the inner and posterior aspects of the second part of the duodenum where the upper two-thirds and lower third of that part meet, there is a small eminence of the mucous membrane, called the **bile papilla.** It lies at the lower end of a vertically-placed valvula connivens, which bifurcates so as to form a kind of cap for it. From the lower part of the papilla a fold extends downwards for some distance, which acts as a bridle, and gives the apex a downward direction. On the summit of this papilla there is an opening which represents the common orifice of the two ducts. These ducts, having traversed the wall of the second part of the duodenum obliquely for $\frac{3}{4}$ inch, unite to form one duct which, before piercing the mucous coat, presents an enlargement called the **ampulla of Vater,** but subsequently narrows at its final ending. In the ampulla of Vater a gallstone may become lodged and delayed in its downward progress toward the duodenum. About 1 inch above the bile papilla there is another small papilla upon which there is another minute opening. This represents the orifice of the accessory pancreatic duct, or duct of Santorini.

The **villi** commence at the beginning of the duodenum on the outer side of the pylorus, and extend as far as the margins of the segments of the ileo-cæcal valve. They are minute projections of the mucous membrane, to which they impart a woolly appearance, and may be visible to the naked eye, but are more readily seen with the aid of an ordinary lens if a portion of bowel is floated in water. They are closely set upon the mucous membrane (valvulæ conniventes included), except over the solitary glands. Their total number is said to be about four millions (Krause). The villi are conical, cylindrical, leaf-like or finger-like processes, varying in length from $\frac{1}{30}$ to $\frac{1}{40}$ inch. They are larger and more numerous in the lower part of the duodenum and in the jejunum, especially at its upper part, than in the ileum, and they diminish both in size and number from above downwards, becoming somewhat filiform in the ileum. Each villus is an elevation of the mucous membrane covered by a single layer of columnar epithelium. It is composed of (1) adenoid tissue, (2) a capillary network of

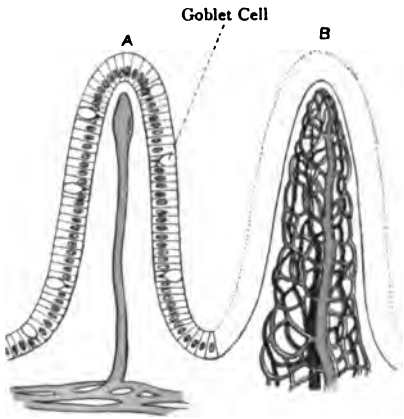


FIG. 330.—TWO VILLI.

A. Villus, showing Striated Basilar Border, Columnar Epithelium, Goblet Cells, and Lacteal Vessel. B. Villus, showing the Capillary Bloodvessels.

bloodvessels, (3) one or more lacteal vessels ensheathed by plain muscular tissue; and (4) arborisations of nerve-fibrils derived from the plexus of Meissner.

Between the columnar epithelial cells of the free surface, many of which are mucus-secreting goblet cells, there are amœboid lymph corpuscles. Beneath the epithelium is a basement membrane composed of flattened cells, and known as the *subepithelial endothelium.* The cells of this basement membrane send processes outwards between the columnar cells of the free surface, and they also send processes inwards which are connected with the branched cells of the retiform tissue of the adenoid tissue. One artery (sometimes two) enters the base of the villus and ascends to near the centre. Here it breaks up into a number of branches, which form a copious capillary network. From this plexus the blood is returned by one or two venous radicles, which leave the villus at its base, where they open into the venous plexus of the mucous membrane. In the centre of the villus there is a **lacteal vessel,** which commences near the tip in a blind bulbous extremity, or, if there should be two lacteals, they originate in the form of a loop. The wall of the lacteal vessel is formed by a single layer of endothelial plates, which are connected by processes with the branched cells of the retiform tissue of the adenoid tissue. The vessel is ensheathed by longitudinal plain muscular fibres derived from the muscularis mucosæ, their fibre-cells being connected with the basement membrane of the villus. The villus is pervaded by adenoid tissue—that is to say, retiform tissue with its meshes filled with amœboid lymph corpuscles. The branched cells of this retiform tissue are connected by processes on the one hand with the endothelial plates which compose the wall of the lacteal vessel, and on the other hand with the cells of the basement membrane near the surface, and these latter in turn send out processes between the columnar epithelial cells of the free surface.

The villi play a most important part in absorption, partly through their copious capillary networks, and partly through their lacteals. The lacteals serve specially for the absorption of fats, which is probably effected in the following manner: the columnar epithelial cells at the free surface take up the saponified and emulsified fats, which they transfer to the amœboid lymph corpuscles between them. These corpuscles then carry the fats inwards through the adenoid tissue into the lacteal vessel.

Brunner's glands are confined to the duodenum, and are serially continuous with the pyloric glands of the stomach. They are very numerous in the commencement of the duodenum, where they form a continuous layer of gland tissue extending as low as the entrance of the common bile-duct and pancreatic duct. Beyond this point they gradually diminish in number, and ultimately disappear near the duodeno-jejunal flexure. They belong to the class of racemose or acino-tubular glands, and they differ from the pyloric glands of the stomach in having their tubules

more branched, and in having longer ducts. Otherwise the structure of the two kinds of glands is similar. Brunner's glands lie embedded in the submucous coat, and their long ducts pass through the whole thickness of the mucous coat, upon the surface of which they open between the crypts of Lieberkühn. Some of them, however, open into these crypts. The glands can easily be displayed by removing the peritoneal and muscular coats of the duodenum and a little of the submucous areolar tissue, when they appear as small, round, grey-coloured masses like millet seeds, varying in diameter from $\frac{1}{12}$ to $\frac{1}{60}$ inch.

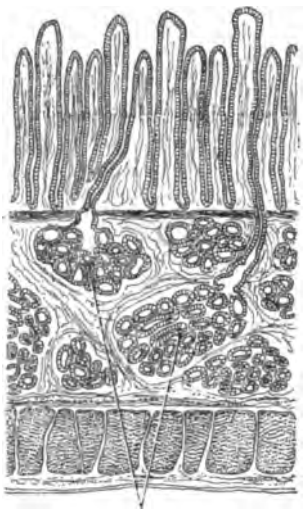


FIG. 331.—SECTION OF THE DUODENUM, SHOWING BRUNNER'S GLANDS (HIGHLY MAGNIFIED).

The **crypts** or **follicles of Lieberkühn** are found in large numbers over the whole of the mucous membrane of the small intestine, as well as that of the large bowel. They belong to the class of simple tubular glands, and are to be regarded as small diverticula of the mucous membrane. Each crypt takes the form of a simple tube, which is closed and slightly enlarged at its deep extremity, and opens by its other end on the surface between the villi. The crypts are present on the valvulæ conniventes as well as in the intervening parts. They are placed vertically and close together, and are confined entirely to the mucous coat, in which they extend from the free surface to the muscularis mucosæ. In length they vary from $\frac{1}{60}$ to $\frac{1}{180}$ inch. Each crypt is composed of a basement membrane lined with columnar epithelium, many of the cells being mucus-secreting goblet cells, and the lumen is of large size.

The **solitary glands** are present over the whole extent of the mucous membrane of the small intestine. They assume the form of small white round or oval nodules, which project by their deep ends into the submucous coat, whilst their superficial ends give rise to slight elevations of the free surface, where they have the openings of the crypts of Lieberkühn placed around them. They are found upon, as well as between, the valvulæ conniventes. In structure each solitary gland is composed of adenoid tissue containing large numbers of lymph corpuscles, and permeated by capillary networks. Each gland is surrounded at its deep part by a copious plexus of lymphatic vessels, or by lymphatic sinuses. The solitary glands are simply lymphoid nodules.

The **agminated glands or Peyer's patches** are peculiar to the

small intestine, and average about thirty in number in the adult, being more numerous in early life. They are situated along the free or anti-mesenteric border of the bowel, which must, therefore, be opened along its attached or mesenteric border in order to preserve them. They are largest, best marked, and most plentiful in the lower half of the ileum. In the upper part of the ileum and

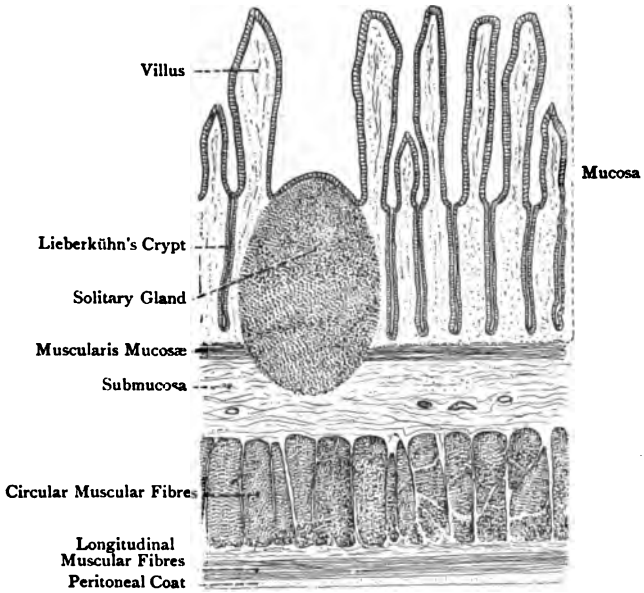


FIG. 332.—VERTICAL TRANSVERSE SECTION OF THE SMALL INTESTINE (HIGHLY MAGNIFIED).

lower part of the jejunum they become smaller and more scarce, and they disappear as a rule above the centre of the jejunum. They vary in length from $\frac{1}{2}$ inch to 4 inches, their breadth ranging from $\frac{1}{2}$ inch to 1 inch. They are for the most part oblong, their long axis coinciding with that of the bowel. In the upper part of the ileum and lower part of the jejunum, however, they are somewhat circular. Each patch is composed of a group of solitary glands or lymphoid nodules, surrounded by lymphatic plexuses or lymphatic sinuses. The area of each patch is slightly elevated, and there are no villi over the lymphoid nodules, whilst the openings of the crypts of Lieberkühn are arranged in a circular manner round each nodule. There are no valvulæ conniventes over Peyer's patches. The patches are best marked in young persons. Towards middle life they fade away, and in old persons they are usually only distinguishable as discoloured portions of the mucous membrane.

Blood-supply—Arteries.—The duodenum receives its arteries from the superior pancreatico-duodenal of the gastro-duodenal from the hepatic, and the inferior pancreatico-duodenal of the superior mesenteric. The jejunum receives its arteries from the rami intestini tenuis of the superior mesenteric. The ileum also receives its arteries from the rami intestini tenuis, and its terminal part in addition receives its arterial supply from the ileal branch of the ileo-colic from the superior mesenteric.

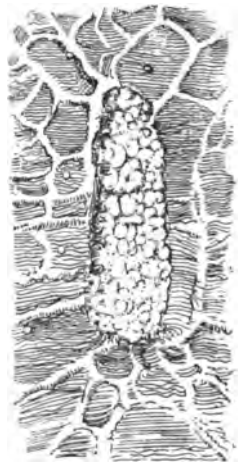


FIG. 333.—A PEYER'S PATCH.

Veins.—The destination of the venous blood of the small intestine is the superior mesenteric vein, and thereafter the vena portæ. The veins are provided with valves which are competent in early life, but in the adult they are incompetent, and therefore allow regurgitation of blood to take place towards the small intestine, as happens in cases of portal obstruction.

Lymphatics.—These form a copious plexus of valved vessels, which is situated in the submucous coat. This plexus receives the lymphatics of the mucous membrane and the lacteals of the villi, and it surrounds the deep ends of the solitary glands. Its efferent vessels pierce the muscular coat, and in doing so they take up the lymph from an intramuscular plexus of lymphatics, which lies between the longitudinal and circular layers. They then leave the bowel at the mesenteric border, where they pass between the two layers of the mesentery, and on their way to the receptaculum chyli they traverse the mesenteric glands.

Nerves.—These are derived from the superior mesenteric sympathetic plexus, and they form two gangliated plexuses of non-medullated nerve-fibres. One of these is situated in the muscular coat between the longitudinal and circular layers, and is known as the **plexus myentericus of Auerbach** (plexus of the muscular coat of the intestine). The other is situated in the submucous coat, and is called the **plexus of Meissner.** The branches of this latter plexus are distributed to the muscularis mucosæ and the mucous membrane with its villi.

Characters of Different Parts of the Small Intestine—Duodenum—*Peritoneum.*—There is no mesentery and only a partial investment of peritoneum. *Muscular Coat.*—This is very thick. *Submucous Coat.*—This contains the tubular portions of Brunner's glands. *Mucous Coat.*—The characters of this coat are as follows: (1) valvulæ conniventes, except in the first 1 or 2 inches, (2) villi, (3) Lieberkühn's crypts, (4) solitary glands, (5) ducts of Brunner's glands, (6) common orifice of the ductus communis choledochus and pancreatic duct, and (7) orifice of the accessory pancreatic duct, or duct of Santorini.

The diameter of the duodenum is from 1¼ to 2 inches.

Jejunum—*Peritoneum.*—There is a mesentery, and the bowel is surrounded by peritoneum except along its mesenteric border. *Muscular Coat.*—This is comparatively thin. *Mucous Coat.*—This has the following characters: (1) valvulæ conniventes, (2) villi in abundance, (3) Lieberkühn's crypts, (4) solitary glands, and (5) Peyer's patches in its lower half.

The diameter of the jejunum is about 1½ inches.

Ileum—*Peritoneum.*—In this respect the ileum resembles the jejunum. *Muscular Coat.* — This is very thin. *Mucous Coat.* — The characters of this coat are as follows: (1) valvulæ conniventes in upper half, but small and sparse, there being none in the lower half; (2) villi, but in fewer numbers; (3) Lieberkühn's crypts; (4) solitary glands; and (5) Peyer's patches.

The diameter of the ileum is about 1¼ inches.

Large Intestine.—The wall of the large intestine, which is sacculated, is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** forms a complete investment to the vermiform appendix, cæcum, transverse colon, and pelvic colon. As regards the ascending colon, descending colon, and iliac colon, it is incomplete, being absent *behind.*

The **muscular coat** (*muscularis externa*) is composed of plain muscular tissue, disposed in two layers—external or longitudinal, and internal or circular.

The *longitudinal muscular fibres* are for the most part collected into three flat bands, called **tæniæ coli,** or **ligaments of the colon,** except upon the rectum. In the intervals between these bands there are some longitudinal fibres, but they are very few and scattered. The tæniæ, which are about ¼ inch in breadth, commence upon the cæcum at the base of the vermiform appendix, and they extend along the several parts of the large intestine as far as the rectum, where they spread out and form a continuous covering, which completely surrounds that part of the bowel. Upon the cæcum, ascending colon, descending colon, and iliac colon the tæniæ from their disposition are called anterior, postero-internal, and postero-external. Upon the transverse colon they are so placed as to be called anterior or omental (great omentum), postero-inferior, and superior or meso-colic (transverse meso-colon). They are shorter than the bowel to which they are applied, with the result that the tube is drawn together or puckered, and thus thrown into sacculi. There being three tæniæ, there are three rows of sacculi between them, and, inasmuch as the tæniæ are placed at nearly equal distances from each other, the sacculi are pretty much of equal dimensions. Between the successive sacculi there are constrictions, usually containing fat. The sacculi give rise internally to large pouches, and the constrictions between the sacculi produce internally sharp crescentic rugæ, which separate the pouches from each other. When the tæniæ are divided, the sacculi and constrictions entirely disappear, and the large bowel becomes elongated into a smooth cylindrical tube. Along the course of the tæniæ there are a number of small processes of peritoneum containing fat, called **appendices epiploicæ.**

Except in the case of the transverse colon, these are chiefly found along the postero-internal tænia, but in the case of the transverse colon they are principally met with along the postero-inferior tænia.

The *circular* fibres are thin and scattered over the sacculi, but in the constrictions between them they become aggregated. Upon the rectum and anal canal they form a thick layer, which in the latter situation is known as the sphincter ani internus.

The **submucous coat** is in all respects similar to that of the small intestine.

The **mucous coat** is pale and greyish in colour, except in the rectum, where it is red. Its epithelium is similar to that of the small intestine. It is destitute of valvulæ conniventes and villi, and consequently presents a smooth surface. It contains large numbers of the crypts or follicles of Lieberkühn, which abound in mucus-secreting goblet cells. It also contains solitary glands or lymphoid nodules, which are especially prevalent in the vermiform appendix and cæcum. The deepest part of the mucous coat is formed by the *muscularis mucosæ* (*muscularis interna*).

Blood-supply—Arteries.—These are as follows: (1) appendicular, for the vermiform appendix; (2) anterior and posterior cæcal, for the cæcum; (3) colic of ileo-colic, and right colic, for the ascending colon; (4) middle colic, for the transverse colon (all branches of the superior mesenteric); (5) left colic, for the descending colon; and (6) sigmoid arteries, for the iliac colon and pelvic colon (the latter two being branches of the inferior mesenteric).

Veins.—The destination of the venous blood of the vermiform appendix, cæcum, ascending colon, and transverse colon is the superior mesenteric vein, whilst the blood of the descending colon, iliac colon, and pelvic colon is carried into the inferior mesenteric vein. In both cases the further destination of the blood is the vena portæ. As in the small intestine, the veins have valves which are competent in early life, but not so in the adult.

The **lymphatics** will be found described on pp. 684 and 685.

Nerves.—These are derived from the superior mesenteric sympathetic plexus, and the inferior mesenteric plexus, which latter is an offshoot from the aortic plexus. The disposition of the nerves corresponds with that in the small intestine.

The large intestine diminishes gradually in size from its commencement to its termination. Its diameter varies in different parts, the extremes being 2½ inches and 1 inch.

Characters of the Large Intestine—*Peritoneal Coat.*—This presents at frequent intervals small projections called appendices epiploicæ. *Muscular Coat.*—The longitudinal fibres are for the most part arranged in three tæniæ. *Mucous Coat.*—This is destitute of (*a*) valvulæ conniventes, (*b*) villi, (*c*) Brunner's glands, and (*d*) Peyer's patches, but it is provided with (1) Lieberkühn's crypts, and (2) solitary glands or lymphoid nodules. *Outline of Tube.*—The bowel presents three rows of sacculi, except in the vermiform appendix and rectum.

Structure of the Vermiform Appendix.—The vermiform appendix is entirely covered by peritoneum, which forms a more or less complete meso-appendix or appendicular mesentery. It has a muscular coat, composed of an external longitudinal and internal circular layer, both of which completely surround it. The

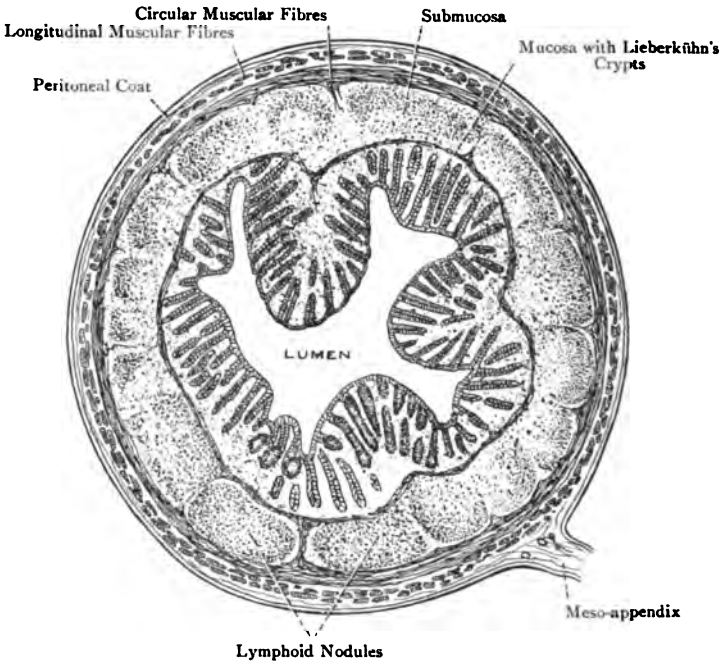


FIG. 334.—TRANSVERSE SECTION OF THE VERMIFORM APPENDIX (HIGHLY MAGNIFIED).

submucous coat contains, in great abundance, lymphoid nodules (solitary glands) of large size, and the mucous coat contains a few lymphoid nodules, as well as a few crypts of Lieberkühn. The base of the appendix is situated at a point on an average rather more than 1 inch below the ileo-cæcal valve according to Treves. The opening by which the appendix communicates with the cæcum is occasionally guarded by a fold of mucous membrane, which is known as the **valve of Gerlach.**

The vermiform appendix is usually regarded as the remains of the herbivorous cæcum. It is also looked upon as an appendage of the lymphoid system, and as such it would belong to the class of structures represented by Peyer's patches, namely, lymphoid organs. In its typical form it is peculiar to man, the higher apes, and the marsupial wombat. In certain rodents, however—*e.g.*, the rabbit and hare—the very large capacious cæcum shows an approach to a vermiform appendix at its lower extremity.

Ileo-cæcal or **Ileo-colic Valve** (valve of Tulpius).—This valve is situated at the point where the terminal part of the ileum opens into the junction between the cæcum and ascending colon. The orifice, as seen from the interior of the large intestine, has the form of a slightly oblique cleft about ½ inch long, and running in an antero-posterior direction. It is bounded above and below by the two segments which form the valve, and which project into the large intestine. The upper or *ileo-colic segment* is crescentic, and occupies a horizontal plane. The lower or *ileo-cæcal segment*, larger than the upper, is also crescentic, and occupies an oblique plane. The anterior part of the cleft is rounded off, whilst the

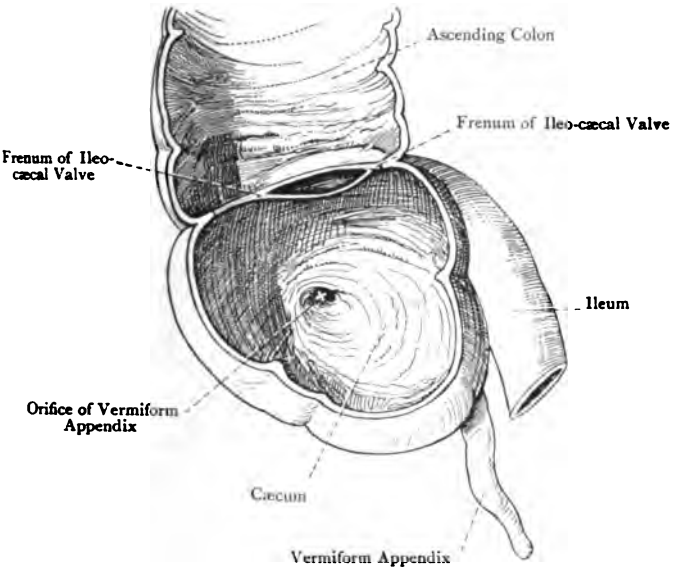


FIG. 335.—THE INTERIOR OF THE CÆCUM AND THE ILEO-CÆCAL VALVE.

posterior part tapers to a point. The segments meet in front of and behind the cleft, and form two prominent folds, which are prolonged round the wall of the bowel for some distance. These folds are known as the *frena* or *retinacula of Morgagni*. Each segment is composed of two layers of mucous membrane, one of which belongs to the ileum, and the other to the cæcum or colon as the case may be. These two layers are continuous with each other at the free margin of the segment, and they contain between them submucous areolar tissue and circular muscular fibres, both of which are derived partly from the ileum and partly from the large intestine. The longitudinal muscular fibres and the serous or peritoneal coat take no part in the formation of the segments, being continued uninterruptedly from the ileum to the large

intestine. The mucous membrane which covers the opposed surfaces of the segments belongs to the ileum, and is, therefore, provided with villi. The mucous membrane of the other surfaces, that is to say, the surfaces which look away from each other (downwards and upwards respectively), belong to the cæcum and colon, and are destitute of villi. The villi thus disappear at the margins of the segments. The valve may be described as being formed by an inversion of the terminal part of the ileum into the large intestine. That part of the ileum, having passed upwards and to the right with a slight inclination backwards, enters the large intestine. As it does so, it leaves behind its serous and longitudinal muscular coats, and takes with it its circular muscular, submucous, and mucous coats, the corresponding coats of the large intestine accompanying it in the inversion. The ileo-cæcal valve prevents the regurgitation of the contents of the cæcum into the ileum. It is generally believed that the mode of action of the valve is as follows: when the cæcum becomes distended the fræna or retinacula of the valve are stretched, and exercise traction upon its segments, which are thereby brought together, very much as an old-fashioned purse is closed by pulling upon the two strings.

For the structure of the rectum, see p. 818.

Development of the Stomach, Intestinal Canal, and Peritoneum.—The primitive alimentary canal, which lies beneath (on the ventral aspect of) the notochord, is limited anteriorly by the head-fold, posteriorly by the tail-fold, and on either side by a lateral fold. It is arranged in three divisions, namely, the fore-gut, the mid-gut, and the hind-gut. The **fore-gut,** which is placed within the head-fold, gives rise to (*a*) the tongue and back part of the buccal cavity, (*b*) the pharynx, (*c*) the œsophagus, (*d*) the stomach, and (*e*) the greater part of the duodenum, as well as the organs developed as outgrowths from these parts. The **mid-gut,** gives rise to (*a*) a part of the duodenum, (*b*) the jejunum, (*c*) the ileum, and (*d*) the large intestine, except a portion of the colon at its lower end, the rectum, and the anal canal. The **hind-gut** is contained within the tail-fold, and gives rise to (*a*) the portion of the colon not developed from the mid-gut, (*b*) the rectum, and (*c*) the portion of the anal canal *above* the anal valves. The portion of the anal canal *below* the anal valves, and the anus are developed from the posterior part of the cloacal fossa, which is called the **proctodæum.** The mid-gut remains for some time in free communication with the yolk-sac. The communication is at first a wide one, but a constriction soon takes place in the region of the umbilical orifice, so that the mid-gut and yolk-sac now communicate by a comparatively narrow neck or duct. The abdominal wall being now formed, and the yolk-sac lying outside the body of the embryo, this duct runs inwards from the yolk-sac along the umbilical cord and through the umbilicus, after which it joins by its other end the mid-gut. The duct is variously known as the *umbilical, vitelline,* or *vitello-intestinal duct.* The part of the mid-gut which is connected with this duct gives rise to the lower portion of the ileum, and the occasional occurrence of **Meckel's diverticulum** in that part of the gut is due to the intestinal portion of the vitelline duct remaining persistent. At this period of embryonic life the primitive alimentary canal has only one opening, namely, that by which it communicates with the yolk-sac through the vitelline duct, its cephalic and caudal ends being closed. It is lined with hypoblast, from which is developed the epithelium of the future alimentary canal, and this hypoblast is covered externally by the visceral or splanchnic layer of the mesoblast, called the **splanchnopleure.** The primitive alimentary canal, thus composed, is separated from the body-

wall (which consists of epiblast and somatopleure) by the body-cavity or **cœlom**, and this latter subsequently becomes partitioned off into pleural, pericardial, and peritoneal cavities. The alimentary canal is closed at either end. Subsequently, however, an invagination of epiblast takes place at either end, which comes into close contact with the hypoblast forming the closed extremities, and in this way the buccal cavity at one end, and the anus and portion of the anal canal *below* the anal valves at the other end, are formed. The anterior invagination is called the **stomatodæum**, and the posterior is known as the **proctodæum**.

Stomach.—Up to the fourth week the primitive alimentary canal is very nearly a straight tube. At that period the first indication of the stomach shows itself as a somewhat spindle-shaped dilatation in the neighbourhood of the embryonic heart, this dilatation being at first practically straight. After the stomach descends into the abdominal cavity its dorsal aspect undergoes greater development than the rest of the organ, and a curve is thereby produced. The convexity of the curve at this period is directed backwards, and the concavity forwards. The surfaces of the organ are right and left respectively, and they thus naturally receive the corresponding pneumogastric nerves. The pyloric end, which at this period is directed downwards, is now tilted forwards towards the anterior abdominal wall, carrying with it the duodenum, and so giving rise to the duodenal loop. As the posterior part of the stomach continues to grow in excess of the anterior part, the organ now undergoes partial rotation towards the right side, and the upper or cardiac end is carried to the left of the middle line, thereby giving rise to the oblique position permanently assumed by the organ. The stomach, in rotating, carries with it the duodenal loop, which thus takes up a position on the right of the middle line. The original right side of the stomach now becomes the posterior surface, and the original left side becomes the anterior surface, *thus accounting for the distribution of the right pneumogastric nerve to the posterior surface in the adult, and of the left to the anterior surface.* The great curvature, which originally looked backwards, now looks downwards and to the left, and the small curvature, which originally looked towards the anterior abdominal wall, now looks upwards and to the right. These changes in the stomach take place in the course of the second month.

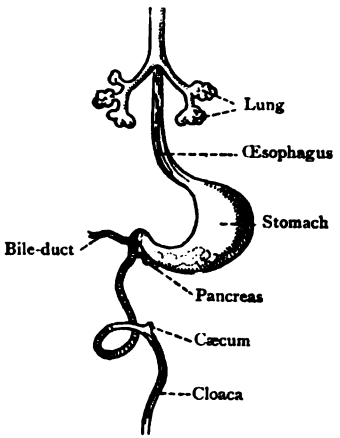


FIG. 336.—THE ALIMENTARY CANAL OF THE EMBRYO (HIS).

Intestinal Canal.—Originally there is no separation of the intestinal tube into small and large intestine. The primitive gut is at first very short and almost straight, there being a slight convexity directed towards the umbilicus. As has been stated, it communicates freely with the yolk-sac by a wide opening. When this opening becomes constricted and converted into the vitelline duct, the intestinal tube undergoes lengthening, and about the fifth or sixth week a budding or outgrowth makes its appearance, which represents the rudimentary cæcum, and is the first indication of the separation of the gut into small and large intestine. Moreover, opposite the place of attachment of the vitelline duct a somewhat horse-shoe loop (U) is formed, the duct being connected with the bend of the loop, and the rudimentary cæcum with its distal limb. This intestinal loop increases in size, and the ends of its limbs, coming together, form a neck, the upper portion of which represents the future duodenum, whilst the lower portion corresponds with the right extremity of the future transverse colon. The mesentery of the loop

contains the superior mesenteric artery. The cæcal protrusion is at first of uniform dimensions, but subsequently its blind end remains narrow so as to form the vermiform appendix, and the rest of the cæcum, together with the colon, becomes enlarged. As the small intestine grows, its mesentery does not keep pace with it, the result being that the gut is thrown into coils. The horse-shoe loop already referred to, when fully formed, attains considerable size, and at first is directed forwards in the middle line towards the anterior abdominal wall. When the coils of the small intestine become formed, they take up a position on the right side of the middle line, whilst the cæcum and colon are placed on the left side. The subsequent transposition of these parts is brought about by a rotation of the horse-shoe loop and its mesentery round an axis represented by the superior mesenteric artery, this rotation taking place from left to right. The result is as follows : (1) the cæcum and ascending colon are transferred from the left to the right side ; (2) the coils of the small intestine, together with the lower part of the duodenum, are carried from the right to the left side ; and (3) the transverse colon is shifted from below the duodenum to its anterior aspect. As regards the mesentery of the horse-shoe loop, its original right side becomes after rotation, the left side, and its original left side becomes the right side. It is to be noted that the portion of gut representing the descending colon never changes its position from the left side.

Cæcum.—The cæcum at first lies on the left side of the middle line, just below the liver. From this position it gradually shifts to the middle line, and then to the right side, still lying just below the liver. Finally, it descends slowly to its permanent abode in the right iliac fossa, though it may be arrested at any point. The migration of the cæcum from its position below the liver on the right side to the right iliac fossa takes place somewhere between the fourth month and the period of birth, though it may be delayed to a later period.

Peritoneum.—The peritoneum is developed from the two layers into which the lateral mesoblast (lateral plate) is cleft, namely, an outer or parietal layer, which adheres to the epiblast and forms the **somatopleure,** and an inner or visceral layer, which adheres to the hypoblast and forms the **splanchnopleure,** of the *cælom* or body-cavity.

Primitive Mesentery.—The primitive alimentary canal is originally attached to the posterior wall of the embryo in the middle line by a mesentery which extends over its whole length. This **primitive dorsal mesentery** is developed from the splanchnopleure which invests the canal, and the names of its several divisions correspond with those of the parts of the canal with which they are connected. Thus, there are the meso-gastrium, meso-duodenum, meso-jejunum, meso-ileum, and so on. In addition to the dorsal mesentery, there is a **ventral mesentery,** likewise mesoblastic, and connected with the ventral aspects of the stomach and duodenum, this latter mesentery being divided by the liver into the falciform ligament and gastro-hepatic omentum.

Changes in the Primitive Dorsal Mesentery—1. **Meso-gastrium.**—This is at first comparatively short, but it undergoes lengthening as the posterior aspect of the stomach grows, and the organ turns round on its right side. During the turning of the stomach the meso-gastrium is doubled upon itself so as to form a kind of bag directed downwards and to the left, the wall of which represents a portion of the gastro-colic omentum. The small sac of the peritoneum is in part developed within this bag, the portion so formed representing the bag or *sac of the gastro-colic omentum.* As the stomach turns round, and the gastro-hepatic omentum changes its position from antero-posterior to transverse, a part of the abdominal cavity is partitioned off behind the stomach and gastro-hepatic omentum, and in this manner the upper part of the small sac becomes formed. This part at first communicates with the rest of the abdominal cavity by a wide opening situated on the right side of the gastro-hepatic omentum. This opening, however, becomes much reduced as the liver grows, and it gives rise to the *foramen of Winslow.* The *gastro-colic omentum* is developed from the bag-like part of the meso-gastrium which grows slowly downwards and to the left over the transverse

colon, and about the fourth month becomes closely adherent to the transverse colon and its meso-colon. For the changes which subsequently take place in it, see p. 678. As regards the *gastro-splenic omentum* and *lieno-renal ligament*, the spleen is developed within the meso-gastrium, and the portion of the latter between the spleen and the stomach forms the gastro-splenic omentum, whilst the part between the spleen and the left kidney gives rise to the lieno-renal ligament.

It is to be noted that, whilst the gastro-colic omentum is developed from a part of the primitive *dorsal* mesentery, namely, the meso-gastrium, the gastro-hepatic omentum is formed by that portion of the *ventral* mesentery which extends between the liver and the stomach, the portion between the liver and the anterior abdominal wall forming the falciform ligament of the liver.

2. **Intestinal Mesenteries**—*Meso-duodenum.*—After the stomach and duodenum turn round on their right side the meso-duodenum, which is a part of the primitive dorsal mesentery, disappears by absorption. *Mesenteries of the jejunum, ileum,* and *large intestine.*—These, which are parts of the primitive dorsal mesentery, are originally continuous throughout. A change, however, takes place after the rotation of the original horse-shoe loop of the gut. The portion of mesentery within the horse-shoe loop forms the mesentery proper of the adult. The dorsal attachment of the mesentery proper is at first extremely limited, being confined to the region of the neck of the horse-shoe loop, where it extends between the duodenum above and the right extremity of the transverse colon below. This part of it contains the superior mesenteric artery, and is continuous with the mesentery of the ascending colon. As, however, development proceeds, it forms a new attachment to the posterior abdominal wall, and, as a rule, becomes cut off from the ascending meso-colon, which latter in most cases becomes removed by absorption. The transverse meso-colon remains persistent. The descending meso-colon and iliac meso-colon are, in most cases, removed by absorption, whilst the pelvic meso-colon remains persistent. The meso-rectum disappears by absorption.

Structure of the Liver.

The **liver** has two coats, external and internal. The *external* or *serous coat* is formed by the peritoneum, and is incomplete (see p. 663). Within the serous coat is the fibrous or areolar coat, which is known as the *fibrous capsule* of the organ. It is for the most part thin, except where the peritoneal coat is deficient. It is continuous all over the surface with the scanty amount of areolar tissue which pervades the interior of the organ and connects the hepatic lobules. At the portal fissure it surrounds the hepatic duct, hepatic artery, and vena portæ, under the name of the *capsule of Glisson.* The subdivisions of this capsule accompany the various branches of the duct, artery, and vein as these ramify throughout the liver in the portal canals. The liver-substance is composed of a great number of small polyhedral masses, called hepatic lobules, which are closely packed together, and are set, each by one surface, on the walls of the sublobular veins, to which they are attached by means of intralobular or central veins. In man there is very little areolar tissue between the lobules, which are therefore for the most part confluent. In some animals, however, notably the pig and camel, there is a very distinct amount of areolar tissue between the lobules, which, therefore, stand clearly apart from each other.

The average diameter of a **hepatic lobule** is $\frac{1}{16}$ inch. One of its surfaces is called the *base*. It is by this surface that the lobule is set upon the wall of a sublobular vein, and the intralobular or central vein, having emerged from the lobule through the centre of its base, opens at once into the sublobular vein. The lobules, therefore, relatively to the sublobular veins, on which they are ranged, are sessile. When a sublobular vein is opened and viewed from within, an appearance something like mosaic work presents itself, the closely-set bases of the lobules being visible through the thin wall of the vein, and the minute openings of the intralobular or central veins appearing in the centre of each base. Each lobule is composed of hepatic cells, permeated by capillary networks of blood-vessels and bile capillaries.

Bloodvessels.—The liver derives its blood from two sources, namely, the vena portæ, and the hepatic artery. These two vessels, together with the hepatic duct, are invested by the capsule of Glisson at the portal fissure. Their several branches, ensheathed by prolongations of Glisson's capsule, ramify from this point throughout the liver, being contained in the system of canals, known as **portal canals.** Each of these canals contains (1) a branch of the vena portæ, (2) a branch of the hepatic artery, accompanied by a plexus of nerves, (3) lymphatic vessels, and (4) a minute duct, all these being loosely surrounded by a prolongation of Glisson's capsule.

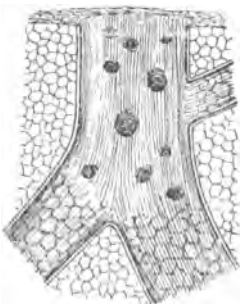


FIG. 337.—SECTION OF THE LIVER, SHOWING A LARGE HEPATIC VEIN AND ITS TRIBUTARIES (AFTER KIERNAN).

The **vena portæ** ramifies within the liver like an artery. In the portal canals its branches receive as tributaries small *capsular* and *vaginal veins*, and they go on ramifying until they arrive at the interlobular areæ. Here they anastomose freely with one another around the lobules, and so form the *interlobular plexuses*. The branches which arise from these plexuses enter the lobules on all sides except their bases, and form in the interior of each lobule an *intralobular plexus*. From this plexus a few radicles converge towards the centre of the lobule, where they form by their union the *intralobular* or *central vein*. The portal blood, though dark in colour, is very rich, being derived from, amongst other sources, the stomach and small intestine.

The **hepatic artery** is a branch of the cœliac axis. As its branches traverse the portal canals they give off *capsular branches* to the fibrous capsule of the liver, and *vaginal branches*, which supply the walls of the vessels in the portal canals, as well as their Glissonian sheaths. The branches of the artery finally end as minute *interlobular arteries*, which supply the walls of the interlobular

veins and bile-ducts. According to some authorities they send minute capillary branches into the interior of each lobule to join the intralobular plexus of the venæ portæ, but this view is not held by others.

The function of the hepatic artery and its branches is to nourish the tissues of the liver, whilst the portal blood supplies the materials which are elaborated by the hepatic cells.

The **hepatic veins** commence in the centre of each lobule as an *intralobular* or *central vein*. The intralobular veins open into the *sublobular veins*, which are closely adherent to the bases of the lobules. The sublobular veins join to form larger sublobular veins, and these in turn terminate in the *hepatic veins*, which are not in direct contact with the lobules. The hepatic veins pass to the caval fossa on the posterior surface of the liver, towards which they converge, taking up sublobular veins in their course. The passages which contain the veins are known as the **hepatic canals.** On arriving at the upper part of the caval fossa they are reduced to two or three in number, which pour their contents directly into the inferior vena cava. It is to be noted that the hepatic veins converge to the caval fissure on the posterior surface, whilst the branches of the vena portæ radiate in all directions from the portal fissure. The hepatic veins are accompanied only by lymphatic vessels, and are surrounded by a very scanty amount of areolar tissue, which explains why they present open mouths when cut across.

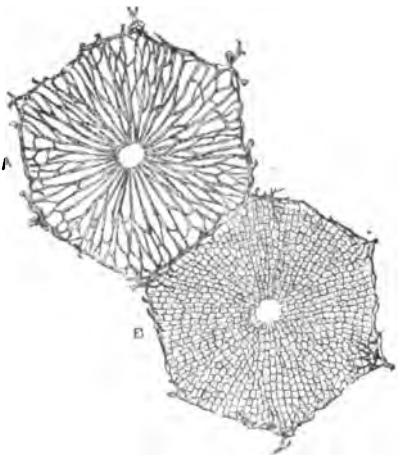


FIG. 338.—TWO HEPATIC LOBULES (HIGHLY MAGNIFIED).

A, Lobule showing the Intralobular Plexus; B, Lobule showing the Hepatic Cells.

Distinguishing Characters of the Hepatic and Portal Veins—Hepatic Veins.—(1) These present open mouths when cut across. (2) They are accompanied only by lymphatic vessels. (3) Their walls are very thin, and are practically in direct contact with the substance of the liver. (4) They converge towards the caval fossa on the posterior surface.

Portal Veins.—(1) The mouths of these veins are practically closed or collapsed when cut across. (2) The veins are accompanied by branches of the hepatic artery, and by ducts. (3) Their walls are fairly thick, and are separated from the substance of the liver by the sheaths derived from Glisson's capsule. (4) They radiate in all directions from the portal fissure in portal canals.

Hepatic Cells.—These are situated within the lobules. They are polyhedral, granular cells, having a diameter of $\frac{1}{1000}$ inch, and each contains a round nucleus. They have no cell-wall, properly

so called, and they are connected by a delicate supporting tissue. The cells, which are capable of amœboid movement, lie between, and around, the capillary vessels, where they are arranged in radiating rows converging towards the centre of the lobule.

Bile-ducts.—These commence within the lobules as *bile-capillaries* or *bile-canaliculi*, which are in reality intercellular passages. They have a very delicate wall, and are bounded on all sides by the hepatic cells—hence the name *intercellular passages*. According to Pflüger and Kupffer, the cells contain *vacuoles*, which communicate by intracellular passages with the bile-capillaries. The hepatic cells intervene between the bile-capillaries and the capillary blood-vessels. At the circumference of the lobule the bile-capillaries pass into the small *interlobular bile-ducts*. These join to form larger ducts, and these in turn go on joining until, on arriving at the portal fissure, only two ducts result, which emerge one from each lobe. These now join to form the *hepatic duct*, and this joins the cystic duct to form the common bile-duct. The walls of the interlobular ducts are very thin, being composed of a basement membrane lined with polygonal epithelium. The larger ducts in the portal canals have thicker walls, which, from without inwards, are composed of a fibro-elastic coat, containing plain muscular tissue, arranged longitudinally and circularly, and a mucous coat lined with columnar epithelium. The mucous membrane of the larger ducts presents numerous openings, which lead into blind mucus-secreting recesses. The structure of the hepatic and common bile-ducts is similar to the preceding, though on an increased scale.

Lymphatics.—These are divided into two sets, superficial and deep.

The *superficial lymphatics* form an intimate plexus beneath the peritoneum, and have different destinations. (1) Those from the mesial portions of the right and left lobes, in the vicinity of the falciform ligament, enter that ligament and pass through the diaphragm into the thorax, where they terminate in the *anterior mediastinal glands*, the efferent vessels of which pass partly to the right lymphatic duct and partly to the thoracic duct. (2) Those from the lateral parts of the supero-anterior surface and from the right lateral surface enter the right and left lateral ligaments and terminate in the *cœliac glands*. (3) Those from the uncovered area pierce the diaphragm between the two layers of the coronary ligament, and terminate in the *caval glands* in contact with the thoracic portion of the inferior vena cava, the efferent vessels of which pass to the thoracic duct. (4) A few lymphatics from the front part of the anterior surface turn round the anterior border and join the superficial lymphatics of the inferior surface, whilst others enter the liver and join the deep lymphatics. (5) The superficial lymphatics of the inferior surface for the most part pass to the portal fissure, where they meet the deep lymphatics, with which they descend between the two layers of the gastro-hepatic omentum to the *hepatic glands* therein situated, and there-

after to the *cœliac glands*. Some, however, from the back part of the inferior surface of the right lobe pass to the *lumbar glands*, whilst others from the back part of the inferior surface of the left lobe go directly to the *cœliac glands*.

The *deep lymphatics* commence in lymphatic spaces situated round the intralobular capillaries. Some of them accompany the branches of the portal vein, whilst others go with the hepatic veins. The former, on arriving at the portal fissure, meet most of the superficial lymphatics of the inferior surface, with which they descend between the two layers of the gastro-hepatic omentum to the *hepatic glands*. The latter accompany the hepatic veins to the caval fossa, and thereafter enter the thorax along with the inferior vena cava to terminate in the *caval glands*.

Nerves.—The nerves of the liver are derived from the hepatic plexus, which is an offshoot of the cœliac plexus, that in turn being derived from the solar plexus of the sympathetic system. The cœliac plexus, though principally composed of sympathetic fibres, is reinforced by a few twigs from the *right* pneumogastric nerve. The hepatic plexus accompanies the hepatic artery to the portal fissure, where it receives branches from the *left* pneumogastric nerve, which have ascended from the antero-superior surface of the stomach between the two layers of the gastro-hepatic omentum. In the liver the nerves, which are chiefly non-medullated, are distributed to the walls of the bloodvessels and ducts, penetrating as far as the interspaces between the hepatic cells.

Development of the Liver.—The liver is of *hypoblastic origin*. It first makes its appearance about the second or third week in the form of two diverticula, which spring from the ventral wall of that part of the fore-gut which forms the duodenum, where they are placed close together. These diverticula extend into a collection of mesoblastic tissue, which lies in front of that portion of the fore-gut which gives rise to the stomach and duodenum, and is known as the *septum transversum* of His. In this septum the development of the liver proceeds in the following manner: the two original diverticula ramify by furnishing solid buds, which form columns, called *hepatic cylinders*. These cylinders, like the primitive diverticula, give off laterally other buds, which form secondary cylinders, and so on. The primary and secondary cylinders, by branching and anastomosing freely, give rise to very intricate reticula, which intermingle with reticula of capillary bloodvessels developed in the surrounding mesoblast. The cords of these reticula give off other buds, which form fresh cylinders, and these in turn branch and anastomose, thus adding greatly to the intricacy of the reticula. The part of the fore-gut from which the primitive diverticula spring becomes everted so as to form a kind of hollow pedicle, into which the primitive diverticula now open. This everted part becomes the *common bile-duct*, and the two primitive diverticula form the *right* and *left hepatic ducts*. As the common bile-duct grows, the liver necessarily becomes shifted away from the duodenal part of the fore-gut. The branches of the ducts which lie in the future portal canals and the interlobular ducts are developed from some of the reticular cell-cylinders, which lose their solid character and become tubular. The lumen of each tube is at first surrounded by polyhedral hepatic cells, which subsequently become transformed into the columnar cells of the ducts. The cylinders which are not tunnelled into ducts give rise to the hepatic cells, which constitute the secreting part of the liver, and between these cells the bile-canaliculi are formed as passages which lead ultimately into the radicle

ducts. As the interstitial connective tissue of the liver becomes increased in amount, the organ undergoes separation into lobules. The liver, as it grows, projects from the septum transversum into the abdominal cavity, carrying with it mesoblastic tissue which forms the ventral mesentery, and the portion of the septum transversum which is left behind forms the principal part of the diaphragm. The part of the ventral mesentery which extends between the liver and the anterior abdominal wall forms the falciform ligament, and the part which extends from the liver to the ventral aspect (subsequently the small curvature) of the stomach forms the gastro-hepatic omentum.

The capillary networks, which intermingle with the reticula formed by the cell-cylinders, become connected, on the one hand, with branches of the embryonic vitelline vein, called *venæ advehentes*, which give rise to the branches of the venæ portæ, and, on the other hand, with vessels, called *venæ revehentes*, which give rise to the hepatic veins. The connective tissue of the liver is developed from the mesoblast.

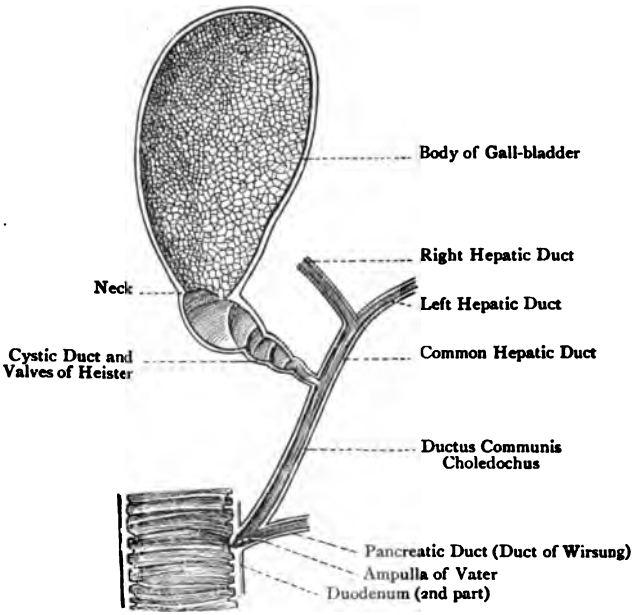


FIG. 339.—THE EXCRETORY APPARATUS OF THE LIVER.

Structure of the Gall-bladder.—The wall of the gall-bladder is composed of three coats—serous, fibro-muscular, and mucous.

The **serous coat** is formed by the peritoneum, and is usually incomplete, being confined to the inferior and lateral surfaces. Sometimes, however, the peritoneum completely surrounds the organ, and attaches its superior surface to the cystic fossa of the liver by a ligamentous fold.

The **fibro-muscular coat** is composed of fibrous and plain muscular tissues. The fibrous bands are disposed in all directions, and interlace freely with one another. The muscular fibres, which inter-

mingle with the fibrous bands, are arranged both longitudinally and transversely.

The **mucous coat** is covered by columnar epithelium. Its surface presents a great number of small ridges, which interlace in all directions and enclose polygonal depressions or alveoli of various sizes. This pitted appearance bears a resemblance to honeycomb, and the mucous membrane of the vesiculæ seminales in the male is similarly arranged. The mucous coat is richly provided with mucous glands. In the neck of the gall-bladder, which describes two curves like the letter **S**, there are two fibro-mucous folds, which project into the interior, one opposite each curve, and serve as valves.

Structure of the Cystic Duct.—The wall of the duct is composed of a fibro-elastic and muscular coat, and a mucous coat. The former resembles that of the gall-bladder. The mucous coat, which is covered by columnar epithelium, presents several crescentic folds, disposed obliquely round the wall in a spiral or somewhat corkscrew manner, and succeeding each other at frequent intervals. When the duct is distended, its exterior presents a series of spiral constrictions with intervening swellings. The spiral folds in the interior serve as valves, which are known as the *valves of Heister*, or of *Amussat*.

Blood-supply.—The gall-bladder is supplied by the **cystic artery**, which is a branch of the right division of the hepatic. Its course is forwards between the hepatic and cystic ducts to the neck of the organ, where it divides into two branches, superior and inferior. The *superior branch* ramifies on the upper surface of the organ, between it and the cystic fossa of the liver, whilst the *inferior branch* is distributed over the inferior surface beneath the peritoneum. The **cystic vein**, which is formed by the union of superior and inferior branches, usually opens into the *right division* of the vena portæ.

Lymphatics.—These pass between the two layers of the gastro-hepatic omentum to the *hepatic glands*.

Nerves.—These are derived from the hepatic sympathetic plexus.

Development of the Gall-bladder and Cystic Duct.—These are formed in the course of the second month as a diverticulum from the common bile-duct.

Structure of the Pancreas.

The pancreas belongs to the class of compound racemose or acino-tubular glands, and bears a close resemblance to a serous or true salivary gland, *e.g.*, the parotid. It has a greyish-pink colour, and is somewhat soft in consistence. It is from 6 to 8 inches long, from 1 to 1½ inches deep, except at the right and left extremities, and from ½ to ¾ inch thick. Its weight is about 3½ ounces. It is destitute of a fibrous capsule, properly so called, and is invested merely by a thin connective-tissue covering, which readily allows the outline of the lobules to be seen.

It is composed of a number of lobules, which are loosely held together by ducts and areolar tissue. Each **lobule** consists of a group of alveoli or acini which are long, tubular, and convoluted, wherein they differ from the saccular alveoli of such a gland as the parotid. From each lobule a duct passes off, which unites with the ducts of adjacent lobules in the left extremity of the gland to form the commencement of the principal duct.

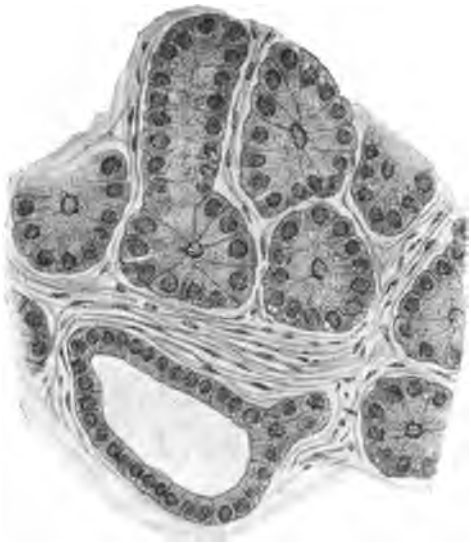


FIG. 340.—STRUCTURE OF THE PANCREAS (HIGHLY MAGNIFIED).

The **alveoli** or **acini** are each composed of a basement membrane, reticular in structure, and lined with columnar epithelium, the basement membrane being continuous with the wall of the duct. The lumen of each acinus is small, and is usually occupied by spindle-shaped cells, which are known as the *centro-acinar cells of Langerhans*. The thin connective-tissue investment, which covers the pancreas externally and connects the lobules at the surface, sends expansions inwards between them, along which the bloodvessels are conducted. Further, the interlobular connective tissue penetrates into the lobules, and so conducts the bloodvessels into their interior. The intralobular or interalveolar connective tissue has a loose disposition, and in certain parts contains isolated groups of epithelium-like cells, which are surrounded by a network of convoluted capillary vessels.

Excretory Apparatus of the Pancreas.—There is one principal duct, called the **pancreatic duct** or **duct of Wirsung.** It is buried in the substance of the gland, and is readily recognised by its white colour. It lies nearer the posterior than the anterior surface, and rather nearer the lower than the upper part of the gland. It commences in the tail, whence it runs through the body as far as the neck, receiving in its course a great many tributaries. On arriving at the neck it gets a branch from the accessory pancreatic duct, and then it describes a bend, and passes into the head in a direction downwards, backwards, and to the right. Finally, on leaving the pancreas it meets with the common bile-duct, and the two, entering the wall of the second part of the duodenum, terminate in the manner already described (see p. 665).

The **accessory pancreatic duct** or **duct of Santorini** is comparatively small, and varies much in size. If well developed, it commences in the lower part of the head, where it takes up the ducts of the lobules of that part. It then passes upwards with an inclination to the right, and divides into two branches. One of

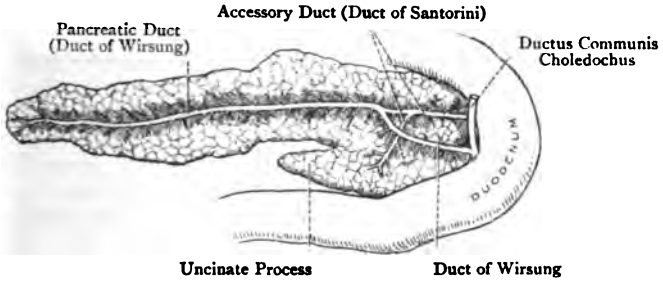


FIG. 341.—THE PANCREAS AND ITS DUCTS (POSTERIOR VIEW).

these joins the duct of Wirsung in the neck, whilst the other opens into the second part of the duodenum at a point about 1 inch above the common opening of the common bile-duct and duct of Wirsung. The secretion conveyed by the duct of Santorini in early life is usually regarded as flowing into the duodenum, whilst in the adult it is diverted into the duct of Wirsung.

The tributaries of the principal duct, as well as of the accessory duct, when followed into the pancreas, become in succession *interlobular* and *intralobular ducts*. The intralobular ducts pass within the lobules, and end in *intermediary*, *junctional*, or *intercalary** *ducts*, with which the alveoli or acini are directly connected. The part of the duct between the intermediary and the intralobular duct is called the *neck*. The walls of the intermediary ducts are thin, and are formed of a basement membrane covered by flattened epithelial cells, the neck being lined by polyhedral cells. In the larger ducts a connective-tissue coat is superadded to the basement membrane, which is now covered by columnar epithelium. The duct of Wirsung, though of comparatively large size, has a thin wall destitute of muscular fibres, and composed of two coats—external fibrous and internal mucous. The mucous coat is smooth and covered by columnar epithelium.

Varieties—(1) **Small Pancreas.**—This consists in a permanent detachment of the unciform process, or that part of the pancreas which extends along the upper aspect of the third part of the duodenum and has the superior mesenteric vessels in front of it. (2) The head of the pancreas may surround the second part of the duodenum more or less completely. (3) **Accessory Pancreas.** When an accessory pancreas is present it is usually met with in the wall of the upper part of the duodenum, but it may be found in the wall of the stomach. (4) The duct of Wirsung sometimes opens into the duodenum independently of, but close to, the common bile-duct.

* Interposed or inserted between the alveoli and the intralobular ducts.

Blood-supply.—The pancreas derives its **arteries** from (1) the pancreatic branches of the splenic artery, one of which accompanies the principal duct from left to right, and is known as the *arteria pancreatic magna;* (2) the superior pancreatico-duodenal of the gastro-duodenal from the hepatic; and (3) the inferior pancreatico-duodenal of the superior mesenteric.

The **veins** are (1) the pancreatic veins, which open into the splenic vein, and (2) the pancreatico-duodenal vein, which terminates in the superior mesenteric vein. All the pancreatic venous blood eventually passes into the portal vein.

Lymphatics.—These commence as lymphatic clefts around the alveoli, and pass chiefly to the *cœliac glands.* Some of them, however, terminate first in the superior mesenteric glands in contact with the upper part of the superior mesenteric artery.

Nerves.—These are derived from offshoots of the hepatic, splenic, and superior mesenteric plexuses, and accompany the arteries. They are chiefly composed of non-medullated fibres.

Development of the Pancreas.—The pancreas is of *hypoblastic origin.* It makes its appearance in the form of two diverticula, one of which springs from the dorsal aspect, and the other from the ventral aspect, of the duodenal portion of the fore-gut, the latter lying close to the hepatic diverticula. The great bulk of the organ is developed from the *dorsal diverticulum.* These diverticula give off laterally hollow offshoots; these in turn give off other hollow offshoots, and so on until, by this ramifying process of sprouting, an acino-tubular gland is built up. The terminal offshoots form the alveoli or acini, whilst the other offshoots form the ducts. The two primary diverticula, though originally separate, unite in the course of the second month. The principal duct is at first connected with the dorsal diverticulum. As development proceeds, the duodenal part of this diverticulum does not keep pace in growth with the ventral diverticulum, and it consequently persists in a vestigial form, under the name of the accessory pancreatic duct or duct of Santorini. The ventral diverticulum exhibits greater growth, and the principal duct of the pancreas (duct of Wirsung), which originally is continuous with the dorsal diverticulum, is now apparently continued into the ventral diverticulum. Eventually the two ducts open separately on the inner and posterior aspect of the bowel, the explanation being that the duodenum, along with the stomach, turns round on its right side, its walls at the same time undergoing disproportionate growth. The ventral diverticulum joins, in most cases, the common bile-duct in the wall of the bowel, though it may open by an independent orifice. The further development of the pancreas takes place between the two layers of the mesogastrium, so that at first it is completely invested by peritoneum, and it occupies a mesial position. When, however, the stomach and duodenum undergo rotation towards the right, the pancreas also turns over on its right side, and then comes to lie across the posterior wall of the abdomen, the peritoneum covering its posterior surface being removed by absorption.

Structure of the Spleen.

The spleen is the largest ductless gland in the body. It has two coats, serous and fibrous, inseparably connected together. The *serous coat* is formed by the peritoneum. The *fibrous coat* or *tunica propria* is composed of fibrous tissue, with a considerable admixture of elastic tissue, and a certain amount of

plain muscular tissue, all of which build up a strong distensible tunic.

The organ is composed of a trabecular network, the spleen pulp, bloodvessels, and Malpighian corpuscles.

The tunica propria sends into the organ a number of trabeculæ which, like the tunica propria, are composed of fibrous, elastic, and plain muscular tissues. These divide and subdivide, and unite with one another, as well as with processes derived from the sheaths which the bloodvessels carry in with them at the hilum. There is thus formed a **trabecular network** which pervades the interior, and contains in its meshes the spleen pulp, capillary tufts, and Malpighian corpuscles.

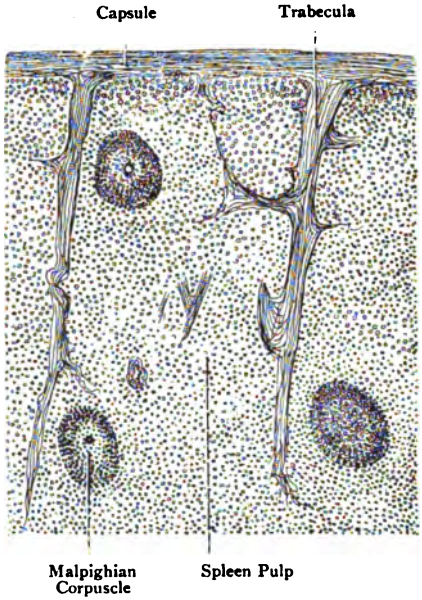


FIG. 342.—SECTION OF THE SPLEEN.

The **spleen pulp** occupies the meshes of the network formed by the trabeculæ. It is soft, and has a dark red colour, which, however, becomes brighter on exposure to the air. The matrix of the spleen pulp is reticular, and is formed by branched connective-tissue corpuscles, which constitute the *sustentacular cells* of the organ. The matrix is, therefore, in reality retiform tissue. The interstices of the reticulum contain blood, in which there is a large number of white corpuscles, and also special cells characteristic of the spleen, and called the *splenic cells*. These latter are of large size, and are amœboid. They contain pigment, and red blood-corpuscles in various stages of disintegration.

Bloodvessels and Malpighian Corpuscles—Arteries.—The splenic artery furnishes five or six large branches which enter the organ at the hilum, and carry in with them trabecular sheaths from the tunica propria. In the interior they divide and subdivide, and finally terminate in pencil-like clusters of capillary vessels, by which time they have laid aside all their coats except the endothelial lining. The endothelial cells then become separated from each other by spaces, and, being continuous with the sustentacular cells of the spleen pulp, the blood flows directly into the interstices of the reticulum of the pulp. The arteries, which are at first accompanied by trabecular sheaths, ultimately lose these sheaths, and

enter the spleen pulp to end in clusters of capillaries. Before they terminate in these clusters their external coat undergoes an important modification, which consists in its transformation into lymphoid or adenoid tissue. This lymphoid tissue forms at intervals small round or oval enlargements, called the **Malpighian corpuscles,** which on section appear as minute white specks in the dark red spleen pulp. These corpuscles are simply localized expansions of the lymphoid tissue which forms the external coat of the small arteries. The expansion may be confined to one side of the artery, or it may include the whole of its circumference. Each corpuscle receives minute twigs from the artery on which it is set, and contains large numbers of lymph corpuscles, as well as capillary bloodvessels.

Veins.—The arterial blood, on leaving the capillary vessels, flows directly into the interstices of the reticular matrix of the spleen pulp, and from these it is taken up by radicle veins which commence in a manner similar to that in which the capillaries end. Endothelial cells, continuous with the sustentacular cells of the pulp, come together and cohere, so as to form very delicate tubular vessels, having closed walls. As these radicle veins unite and become larger the usual other coats are superadded to the endothelial lining. Ultimately five or six veins leave the spleen at the hilum, which unite to form the splenic vein, this in turn uniting with the superior mesenteric vein to form the vena portæ.

It is to be noted that, in the circulation through the spleen, the arterial blood leaves tubular vessels and flows through the interstices of the reticulum of the spleen pulp, where it bathes the Malpighian corpuscles, after which it enters tubular vessels of the nature of veins.

The **cells of the spleen** are of three kinds as follows: (1) the sustentacular cells of the retiform tissue of the spleen pulp; (2) the splenic cells; and (3) lymphoid corpuscles.

Lymphatics.—These are arranged in two groups—trabecular and perivascular. The *trabecular lymphatics* are contained in the trabeculæ, and communicate with a lymphatic network in the tunica propria underneath the peritoneal coat. The *perivascular lymphatics* commence in the lymphoid tissue which forms the external coat of the smaller arteries. At the hilum both sets of lymphatics meet and pass to the *splenic glands*, and thence to the *cœliac glands*.

Nerves.—These are derived from the splenic plexus, which is an offshoot from the cœliac plexus of the solar plexus. The fibres, which are mostly non-medullated, are derived partly from the sympathetic system and partly from the right pneumogastric nerve.

Development of the Spleen.—The spleen is developed within the mesogastrium in close relation with the pancreas, but, whilst the pancreas is of *hypoblastic* origin, the spleen is developed from the *mesoblast*. It first makes its appearance in the second month, at which period the mesoblastic tissue becomes permeated by bloodvessels; but this takes place slowly, and the

Malpighian corpuscles are the last constituent elements to be formed. In its growth towards the left side the spleen carries with it the left layer of the mesogastrium, and from this there are formed the gastro-splenic omentum and lieno-renal ligament.

Structure of the Suprarenal Capsules.

The **suprarenal capsules** or **bodies** (*adrenals*) belong to the so-called ductless glands. Each capsule is enclosed in a thin sheath of connective tissue, from the deep part of which processes are given off into the interior, where they form a supporting stroma. The proper substance of the capsule is divided into an external or cortical, and internal or medullary part.

The **cortical part** has a somewhat yellowish tint, and is composed of cells supported by a fibrous stroma. The cells being variously arranged in different parts, the cortex is divisible into three zones, named, from without inwards, zona glomerulosa, zona fasciculata, and zona reticularis. The **zona glomerulosa,** which is narrow, lies immediately within the external capsule, and is so named because its component cells are grouped in such a manner as to form glomeruli, which are embedded in a fibrous stroma. The cells are polyhedral, and each contains a clear round nucleus. The **zona fasciculata** forms the chief part of the cortex, and is so named because its component cells are arranged in columns or fasciculi. The cells are similar to those of the zona glomerulosa, and the cell-columns are separated from one another by fibrous trabeculæ, which act as carriers of the bloodvessels, nerves, and lymphatics. The **zona reticularis,** which is narrow, lies within the zona fasciculata, and is so named because its component groups of polyhedral cells are connected with one another in such a manner as to form a reticulum.

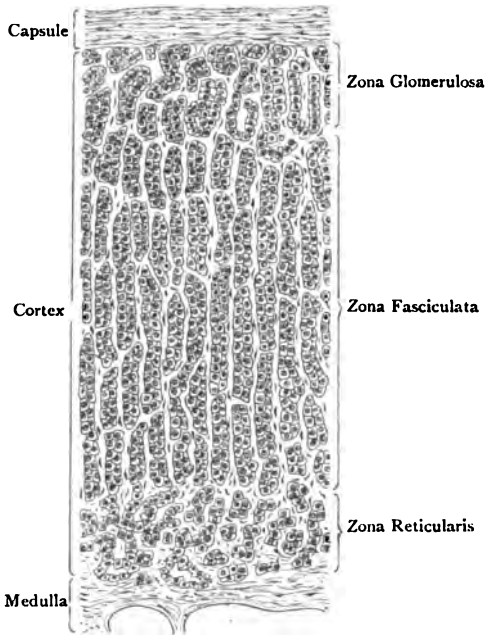


FIG. 343.—SECTION OF THE SUPRARENAL CAPSULE.

The **medullary part** is confined to the centre of the capsule in the adult, is soft in consistence, and has a reddish-brown colour, due to the contained venous blood. The supporting fibrous stroma of the cortex pervades it, and is arranged in a reticular manner. The meshes of this reticulum are occupied by cells, resembling somewhat epithelial cells, and larger and more irregular than those of the cortex, some of them being branched.

Blood-supply—Arteries.—These are (1) the superior capsular of the inferior phrenic or diaphragmatic from the abdominal aorta, (2) the middle capsular from the abdominal aorta, and (3) the inferior capsular from the renal.

The **veins** of each capsule eventually unite to form one suprarenal vein. This vessel emerges through the hilum, and on the *right* side it opens directly into the inferior vena cava, whilst on the *left* side it terminates in the left renal vein.

The **lymphatics** terminate in the *median lumbar glands*.

Nerves.—The suprarenal capsules are very richly supplied with nerves, which are derived from (1) the inferior or diaphragmatic plexus from the semilunar ganglion of the solar plexus, (2) the suprarenal plexus from the semilunar ganglion and cœliac plexus, and (3) offshoots from the renal plexus. According to Bergmann the suprarenal capsules also receive fibres from the phrenic and pneumogastric nerves. The fibres, which are chiefly non-medullated, form rich plexuses in the medullary part, where they have numerous ganglion cells connected with them.

Development of the Suprarenal Capsules—Cortex.—The cortical part is of *mesoblastic origin*. According to some authorities its cells are derived from the cellular columns of the capillary tufts (Malpighian corpuscles) of the Wolffian body, but according to others the cells are derived from the germinal epithelium. **Medulla.** — According to one view the medullary part is developed from cells which grow out from the cellular column representing the rudimentary sympathetic cord and become invested by the cortex. The other view is that the cells of the medulla are derived from those of the cortex.

Structure of the Kidneys.

The kidneys are compound tubular glands. Each organ is invested by a capsule, composed of fibrous tissue with a certain amount of elastic fibres. The deep surface of this capsule is attached to the peripheral portion of the renal substance by fine fibrous processes and small bloodvessels. Underneath it there is a certain amount of plain muscular fibre-cells, arranged in a somewhat plexiform manner. At the hilum on the inner border it is prolonged inwards to line a cavity to which the hilum leads, called the *sinus*, where it becomes continuous with the fibrous coats of the calices.

When a kidney is cut into two halves by a longitudinal incision carried from the outer to the inner border, it is seen to be composed of two parts—cortical and medullary.

The *medullary part*, which is internal in position, is arranged in

conical bundles, termed the *pyramids of Malpighi*, which vary in number from eight to eighteen, the average number being about twelve. The bases of these pyramids are directed towards the circumference, whilst their apical parts, called *papillæ*, project into the sinus, where they are grasped by the calices. Each Malpighian pyramid is divided into three parts, namely, the *boundary zone* or *basal part*, the *papillary zone*, and the *apex*. The boundary zones of the pyramids form collectively the *boundary* or *intermediate layer* of the kidney. They abut against the cortical substance, which sends prolongations between them, called *septula renum* or

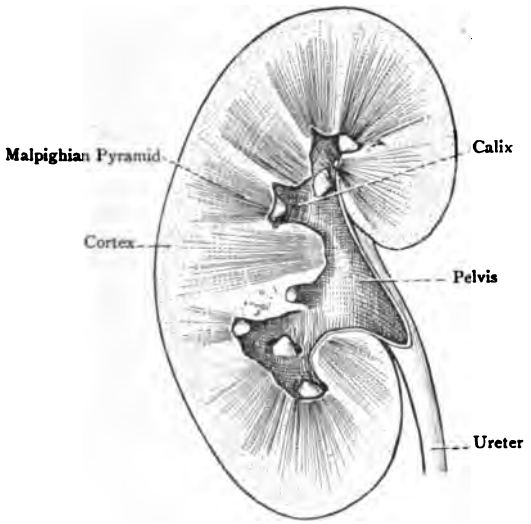


FIG. 344.—DIAGRAM OF THE KIDNEY IN LONGITUDINAL SECTION.

columnæ Bertini. These prolongations extend as far as the commencement of the apical parts of the papillary zones, where they cease, so that these apical parts project into the calices free from cortical investments. Each Malpighian pyramid is composed of straight, slightly diverging uriniferous tubules (*tubuli recti*) and straight bloodvessels, the number of tubules being very much greater in the boundary zone or basal part than elsewhere. This straight arrangement of tubules and bloodvessels imparts to each pyramid a longitudinally striated appearance from apex to base. The boundary zones or basal parts have a dark reddish-brown colour, which becomes brighter in the papillary zones.

The *cortical part* of the kidney is mainly situated within the fibrous capsule. It has a reddish-brown colour and, as already stated, sends prolongations between the Malpighian pyramids. Like the medullary part, it is composed of uriniferous tubules and bloodvessels, but the tubules are principally convoluted (*tubuli*

contorti), though there are also bundles of straight tubules (*tubuli recti*) which have issued from the Malpighian pyramids, and form the *medullary rays* or *pyramids of Ferrein*.

Cortex.—The cortical part is composed of the labyrinth and the medullary rays or pyramids of Ferrein.

Labyrinth.—This portion of the cortex is so named from the very complicated arrangement of its tubules. It is situated in the interspaces between the medullary rays, and is composed of convoluted uriniferous tubules, bloodvessels, and Malpighian corpuscles, each of which corpuscles is enclosed within a capsule of Bowman.

Uriniferous Tubules.—Each tubule commences in the labyrinth of the cortex in a spherical dilatation, called the *capsule of Bowman*, within which there is a tuft of convoluted capillary bloodvessels, known as a *glomerulus* (Ruysch) or *Malpighian corpuscle*. Bowman's capsule presents two poles. One of these is formed by two bloodvessels, afferent and efferent, which pierce the capsule at separate points, but close to each other. At the other pole Bowman's capsule becomes constricted, and forms the **neck** of a cylindrical tubule. After the tubule has passed the neck it becomes convoluted, and forms the *first* or *proximal convoluted tubule*. The basement membrane and lining epithelium of Bowman's capsule are continuous with the basement membrane and lining epithelium of the proximal convoluted tubule, and the space between Bowman's capsule and the glomerulus is continuous with the lumen of the tubule. The proximal convoluted tubule soon becomes straight, though slightly wavy, and, entering a medullary ray, it forms the *spiral tubule*. This tubule, on reaching the junction of the cortex and boundary layer, becomes suddenly very narrow, and traverses the boundary zone of a Malpighian pyramid. It is known as the *descending tubule of Henle*. On leaving the boundary zone it enters the papillary zone, and after a short course it describes a very sharp bend, called the *loop of Henle's tubule*. It now retraces its steps from the papillary zone into the boundary zone of a Malpighian pyramid, in which latter situation it becomes suddenly enlarged. This part, which retraces its steps, is called the *ascending tubule of Henle*. It re-enters the cortex, where it becomes narrower, and passes into a medullary ray, in which it lies for a short distance. It subsequently, however, leaves the ray, and, entering the labyrinth, winds between the convoluted tubules as the *irregular* or *zigzag tubule*, which has become slightly enlarged. This zigzag tubule then passes into the *second* or *distal convoluted* (*intercalary*) *tubule*. This tubule, becoming narrow, passes into the *junctional* or *collecting tubule*, which is slightly wavy. The junctional tubule leads into the *straight collecting tubule* which is slightly enlarged, and is situated in a medullary ray. This straight collecting tubule now passes to the boundary zone of a Malpighian pyramid, taking up in its course other junctional tubules from the labyrinth. In passing through the various parts of a Malpighian pyramid the straight collecting tubules unite at

acute angles, and so become less numerous and at the same time larger. They run in straight, slightly converging lines towards the apex of a papilla, where they are very much reduced in numbers,

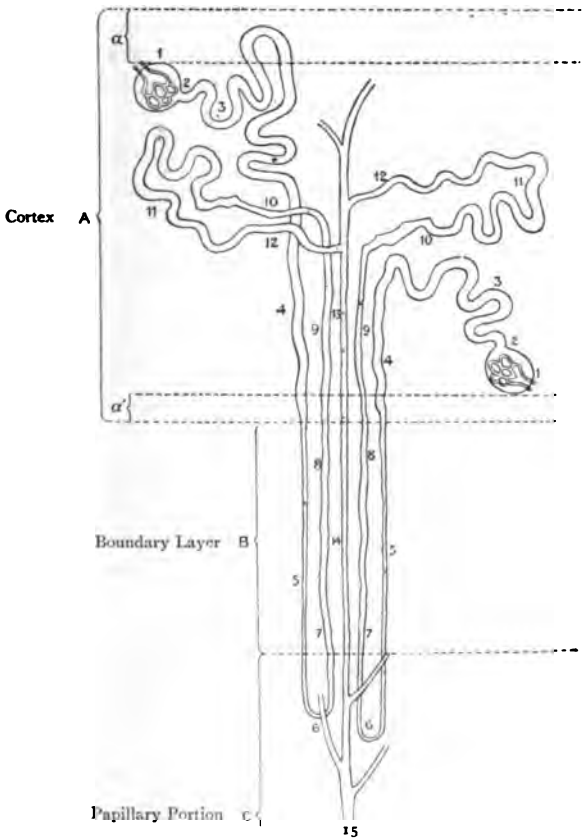


FIG. 345.—DIAGRAM OF THE URINIFEROUS TUBULES OF THE KIDNEY (KLEIN).

a and *a'*, Outer and Inner Zones of Cortex, which are free from Malpighian Corpuscles.

1. 1. Capsule of Bowman
2. 2. Neck of Capsule
3. 3. Proximal Convoluted Tubule
4. 4. Spiral Tubule
5. 5. Descending Limb of Henle's Loop
6. 6. Loop of Henle
7. 7., 8. 8., 9. 9., Ascending Limb of Henle's Loop
10. 10. Irregular Tubule
11. 11. Distal Convoluted Tubule
12. 12. Junctional Tubule
13., 14. Straight Collecting Tubule
15. Excretory Tube or Duct of Bellini

but of large size. In this final part of their course each straight collecting tubule forms the *excretory tube* or *duct of Bellini*. These excretory tubes open on the apex of a papilla, where there is often

a *foveola* or small depression, and through these openings the urine escapes into a calix.

The diameter of the excretory tubes or ducts of Bellini is about the $\frac{1}{200}$ inch.

Summary of a Tubule from Beginning to End.

1. The **capsule of Bowman,** containing a glomerulus or Malpighian corpuscle, in the *labyrinth.*
2. The **neck,** in the *labyrinth.*
3. The **first** or **proximal convoluted tubule,** in the *labyrinth.*
4. The **spiral tubule,** in a *medullary ray.*
5. The **descending tubule of Henle** (small), in a *boundary zone,* and in *part of a papillary zone,* of a *Malpighian pyramid.*
6. The **loop of Henle's tubule,** in a *papillary zone.*
7. The **ascending tubule of Henle** (large), in *part of a papillary zone,* a *boundary zone,* and the *cortex,* in which latter it is in a *medullary ray.*
8. The **irregular** or **zigzag tubule,** in the *labyrinth.*
9. The **second** or **distal convoluted (intercalary) tubule,** in the *labyrinth.*
10. The **junctional tubule,** in the *labyrinth* on its way to a medullary ray.
11. The **straight collecting tubule,** in a *medullary ray* of the *cortex,* and in a *boundary zone* of a *Malpighian pyramid.*
12. The **excretory tube,** or **duct of Bellini,** in a *papillary zone* of a *Malpighian pyramid.*

Structure of the Uriniferous Tubules.—The tubules are composed of a basement membrane lined with a single layer of epithelial cells. The basement membrane itself consists of flattened epithelial cells. The tubules vary in size, but their average diameter may be stated as $\frac{1}{60}$ inch. The characters of the lining epithelial cells present differences in the different tubules, which will now be considered in order.

1. The **capsule of Bowman** is lined with a single layer of *flattened epithelium,* which is reflected over the glomerulus or Malpighian corpuscle, where it is more distinct in early life than in the adult.
2. The **neck** is lined with *cubical epithelium.*
3. The **first** or **proximal convoluted tubule** is also lined with *cubical epithelium,* but the cells, which are thick, are peculiar. The inner part of each cell—that is the part next the lumen of the tubule, including the spherical nucleus, has *granular* protoplasm, whilst the outer part—that is, the part next the basement membrane—has its protoplasm *striated* or *fibrillated,* owing to the presence of rod-shaped fibrils disposed vertically to the basement membrane (Heidenhain). These fibrillated cells are provided laterally with processes, by which they embrace one another. The lumen of the tubule is distinct.
4. The **spiral tubule** is lined with epithelium similar to that of the proximal convoluted tubule, and its lumen is distinct.
5. The **descending tubule of Henle** is lined with clear, thin, *flattened cells.* The tubule, though narrow, has a distinct lumen.
6. The **loop of Henle's tubule** is lined with epithelium which resembles that of the descending tubule.
7. The **ascending tubule of Henle** is lined with *fibrillated, cubical epithelial cells* like those of the proximal convoluted and spiral tubules. Though it is of comparatively large size, its lumen is small.
8. The **irregular** or **zigzag tubule** is lined with *cubical epithelial cells,* which are markedly fibrillated, and its lumen is minute.
9. The **second** or **distal convoluted tubule** is lined with epithelium which resembles that of the proximal convoluted tubule, with the following differences: (*a*) the cells are longer; and (*b*) they are highly refractive. In size it corresponds with the proximal convoluted tubule.
10. The **junctional tubule** is lined with clear *flattened, cubical epithelial cells,* and its lumen is large.

11. The **straight collecting tubule** is lined with epithelial cells, which, in its earlier part, are clear and *cubical*, but in its later part they are *columnar*, and the lumen is very distinct.

12. The **excretory tube** or **duct of Bellini** is lined with epithelial cells which are clear and *columnar*.

Medullary Rays or *Pyramids of Ferrein.*—These take the form of pyramidal bundles of uriniferous tubules, which are separated from each other by portions of the labyrinth. The tubules are straight, and emerge from the boundary zones of the Malpighian pyramids. As these medullary rays are followed from the boundary zones to the periphery, each gradually diminishes in breadth, and ultimately tapers to a point, which stops a short distance from the fibrous capsule, being separated from it by a portion of the labyrinth. The rays are thus conical, their bases being at the boundary zones of the Malpighian pyramids, and their apices near the fibrous capsule—hence the name 'pyramids.' The explanation of this shape is that the tubules at the circumference of a medullary ray enter the labyrinth sooner than those in the centre, which latter form the apex of the ray.

Summary of a Medullary Ray.—Each contains the following tubules: (1) spiral tubules; (2) ascending tubules of Henle; and (3) straight collecting tubules.

Medulla of the Kidney.—The medullary portion has been already generally described. It is composed of Malpighian pyramids, consisting of uriniferous tubules and bloodvessels (true and false).

The tubules in the various parts of the Malpighian pyramids are as follows:

1. *Boundary Zone.*—This contains the following tubules:
   Portions of the **descending tubules of Henle.**
   Portions of the **ascending tubules of Henle.**
   Straight collecting tubules.
2. *Papillary Zone.*—This contains the following tubules:
   Portions of the **descending tubules of Henle.**
   The **loops of Henle's tubules.**
   Portions of the **ascending tubules of Henle.**
   The **excretory tubes** or **ducts of Bellini.**
3. *Apex of the Papillary Zone.*—This contains only the **excretory tubes** or **ducts of Bellini.**

Bloodvessels of the Kidneys—Arteries.—Each kidney receives a large amount of blood from the renal artery, which is a branch of the abdominal aorta. This vessel, as it approaches the hilum, divides into four or five branches, which enter the sinus, where they are embedded in fat along with the calices. They then subdivide into **interlobar branches,** which pass between the Malpighian pyramids, where they continue to subdivide. On arriving at the junction of the cortex and boundary layer they form a series of arches, which are independent of one another, and are called the **cortico-medullary arches.** Alongside of these there are venous arches, which, unlike the arterial arches, anastomose freely with

one another. The convexities of the incomplete arterial arches are directed towards the cortex, and the concavities towards the Malpighian pyramids. The branches of the arches are interlobular and arteriæ rectæ.

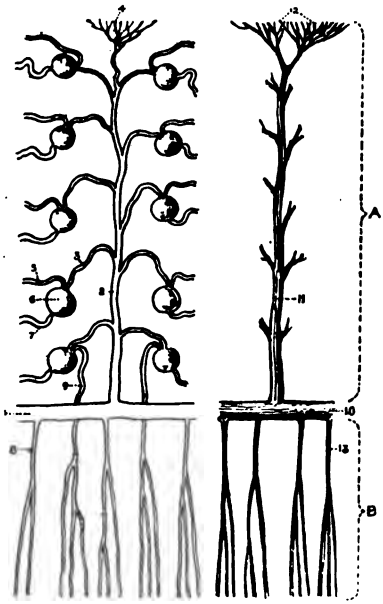


FIG. 346.—DIAGRAM OF THE BLOOD-VESSELS OF THE KIDNEY.

A, Cortex; B, Medulla.

1. Arterial Arch
2. Interlobular Artery
3. Afferent Artery of Glomerulus
4. Capsular Branches
5. Efferent Vessel of Glomerulus
6. Malpighian Corpuscle
7. Proximal Convoluted Tubule
8. True Arteria Recta
9. False Arteria Recta
10. Venous Arch
11. Interlobular Vein
12. Venæ Stellatæ
13. Venæ Rectæ

The **interlobular arteries** (cortical) arise from the convexities of the arches and enter the labyrinth of the cortex, in which they pass outwards between the medullary rays. They give off afferent and capsular branches.

The *afferent branches* are so named because they carry blood to the glomeruli or Malpighian corpuscles. They arise from the interlobular arteries at frequent intervals, and each passes to a capsule of Bowman without giving off any branch. Having pierced the capsule at one pole, the afferent vessel breaks up into a number of convoluted capillary vessels, which form a small vascular ball, called a **glomerulus** or **Malpighian corpuscle.** The blood is conveyed away from the glomerulus by an *efferent vessel*, which is variously regarded as an artery and a vein. This efferent vessel is smaller than the afferent artery. It pierces Bowman's capsule at the same pole as the afferent artery, but separate from, though close to, it. Thereafter it breaks up into a network of capillary vessels, which invest the corresponding proximal convoluted uriniferous tubule, the meshes of the network being polygonal. The efferent vessels of those glomeruli which lie nearest to the Malpighian pyramids are disposed in a different manner. They break up into bundles of straight vessels, called *false vasa recta*, which enter the boundary zones or basal parts of the pyramids, where they supply to a large extent the uriniferous tubules, upon the walls of which they form capillary networks with elongated meshes. It is, however, to be noted that the Malpighian pyramids also receive true arteriæ rectæ from the cortico-medullary arterial arches.

Malpighian Corpuscles.—A Malpighian corpuscle of the kidney is a **glomerulus** or small ball of convoluted capillary bloodvessels, having two vessels connected with it, one of which is an afferent artery and the other an efferent vessel. The vessels of many of the corpuscles are collected into bundles, an arrangement which renders these corpuscles lobulated, the number of lobules varying from two to five. Each corpuscle lies within a capsule of Bowman, and the flattened epithelium of the capsule is reflected over the corpuscle from the points of entrance and exit of the afferent and efferent vessels. The epithelial cells covering the corpuscle are thicker and less flattened than those lining the capsule of Bowman, and are better marked in early life than in the adult. In the case of the lobulated corpuscles the epithelial investment dips in between the component lobules. The epithelium of Bowman's capsule and the epithelium of the corpuscle, which in each case forms a single layer, are separated from one another by a slight interspace. The diameter of a Malpighian corpuscle is about $\frac{1}{200}$ inch. The corpuscles are confined to the cortex of the kidney, where they lie in rows in the labyrinth between the medullary rays. There is a narrow zone immediately within the external capsule, and another narrow zone close to the Malpighian pyramids, from both of which Malpighian corpuscles are absent.

FIG. 347.—DIAGRAM SHOWING A MALPIGHIAN CORPUSCLE OF THE KIDNEY WITH ITS AFFERENT AND EFFERENT VESSELS, AND A PROXIMAL CONVOLUTED TUBULE WITH ITS VENOUS PLEXUS (BOWMAN).

1. Glomerulus
2. Bowman's Capsule
3. Uriniferous Tubule
4. Interlobular Artery
5. Afferent Vessel
6. Efferent Vessel
7. Venous Plexus around Tubule
8. Interlobular Vein

The *capsular branches* of the interlobular arteries supply the external fibrous capsule of the kidney, in which they anastomose with branches of the lumbar arteries from the abdominal aorta.

The **arteriæ rectæ** (medullary), or vasa recta (true), arise from the concavities of the cortico-medullary arterial arches, and at once enter the boundary zones or basal parts of the Malpighian pyramids. Here they break up into bundles of straight, slightly diverging arterioles, which run between the bundles of straight, slightly converging uriniferous tubules, a mutual arrangement which imparts to the Malpighian pyramids a longitudinally-striated appearance. The capillary networks formed by these arterioles have necessarily elongated meshes. It is to be noted that the Malpighian pyramids derive their blood-supply from two sources, namely, (1) the arteriæ rectæ, or vasa recta (true), from the cortico-medullary arterial arches, and (2) the false vasa recta from the efferent vessels of those glomeruli which lie nearest the Malpighian pyramids. It is also to be noted that a Malpighian corpuscle of

the kidney is a ball of convoluted capillary bloodvessels, which is enclosed within a capsule of Bowman, whereas a Malpighian corpuscle of the spleen is a collection of lymphoid or adenoid tissue which is a localized expansion of the external or lymphoid coat of the small arteries in the interior of that organ.

Veins—*Veins of the Cortex.*—These are called the *interlobular veins.* Some of them commence on the surface of the kidney beneath the capsule, from which they return blood, and these are called *venæ stellatæ*, because the venous radicles which give rise to them converge to a point, and so present a star-like appearance. Others originate in the plexuses around the uriniferous tubules. The interlobular veins terminate by joining the convexities of the venous arches, which are situated between the cortex and the Malpighian pyramids.

Veins of the Medulla.—The veins of the Malpighian pyramids commence in plexuses which surround the excretory tubes or ducts of Bellini in the apical parts of the papillary zones, and they are called *venæ rectæ.* As these traverse the pyramids they are collected into bundles of straight vessels, which open into the concavities of the cortico-medullary venous arches.

Cortico-medullary Venous Arches.—These arches, which are complete, are situated between the cortex and the Malpighian pyramids, where they lie alongside of the incomplete arterial arches. They derive their blood from the interlobular veins of the cortex, and the venæ rectæ of the Malpighian pyramids. The veins which proceed from these arches pass between the pyramids to the sinus of the kidney, where they unite to form the renal vein, which terminates in the inferior vena cava.

Lymphatics.—These consist of two groups, superficial and deep. The **superficial lymphatics,** which are few in number, form a plexus in the fibrous capsule, and communicate with lymph spaces between the uriniferous tubules in the outer part of the cortex. They terminate by joining the deep lymphatics at the hilum. The **deep lymphatics** accompany the bloodvessels, and communicate with lymph spaces between the uriniferous tubules of the cortex and boundary layer. On emerging at the hilum they receive the superficial lymphatics, and then pass to the *median group* of *lumbar glands.*

Nerves.—The kidney receives numerous nerves from the renal plexus, which derives its fibres from (1) the aortico-renal ganglion, in which the small splanchnic nerve terminates; (2) the cœliac plexus; and (3) the aortic plexus. If there is a least splanchnic nerve present it reinforces the renal plexus. The nerve-fibres are partly sympathetic, partly spinal through the small and least splanchnic nerves, and in part derived from the right pneumo-gastric through the cœliac plexus. They accompany the arterial branches, and ramify upon the walls of the vessels and uriniferous tubules.

Excretory Apparatus of the Kidney.—This consists of the calices or infundibula, pelvis, and ureter.

Ureter.—This is the excretory duct of the kidney, and it has the form of a cylindrical tube, like a goose-quill, its colour being a dull white. Its length varies from 12 to 16 inches, and its diameter is about $\frac{1}{5}$ inch. At its lower extremity it opens into the bladder, and at the hilum of the kidney it presents a dilatation called the **pelvis of the kidney,** which is funnel-shaped, being wide above and narrow below. The pelvis is flattened from before backwards, and lies partly in the sinus and partly outside the hilum, its direction being downwards and inwards. It breaks up into two or three primary divisions within the sinus, and these again form secondary divisions, the resulting tubes being called **calices** or **infundibula,** which vary in number from 7 to 13. The number of calices thus falls short of the number of Malpighian pyramids (8 to 18), the explanation being that one calix grasps two papillæ or even three. The calices embrace the papillæ of the Malpighian pyramids, which thus project into them, and they receive the urine as it oozes through the pores on the apices of the papillæ, these pores being the openings of the excretory tubes or ducts of Bellini. The interspaces between the calices in the sinus are occupied by the branches of the renal bloodvessels and by fat.

Structure of the Ureter.—The ureter is a thick-walled muscular tube, lined with mucous membrane, and it consists of three coats—external or fibrous, middle or muscular, and internal or mucous. The **fibrous coat** is composed of fibrous tissue, very compactly arranged, and it contains the bloodvessels and nerves, which here subdivide. The **muscular coat** is composed of plain muscular tissue, which is disposed in three layers—*outer longitudinal, middle circular,* and *internal longitudinal.* The outer longitudinal layer is best marked in the lower half of the ureter, where it forms a continuous investment. In the upper half of the tube its bundles are somewhat scattered. The **mucous coat** superiorly is continued over the papillæ of the Malpighian pyramids, and inferiorly becomes continuous with the mucous membrane of the bladder. It is covered by stratified transitional epithelium, the cells being arranged in four layers. In the most superficial layer (nearest the lumen of the tube) the cells are cubical, and present depressions on their deep surfaces, which receive the round ends of the pyriform cells of the layer beneath. In the second layer the cells are pyriform, the round superficial ends being capped by the cubical cells of the first layer, and the narrow deep ends projecting between the deeper cells. In the third and fourth layers the cells are round or oval. The mucous membrane is thrown into longitudinal folds, and the lumen of the tube, which is of small size, presents under the microscope a branched appearance in cross section.

Blood-supply—Arteries.—The ureter receives branches from the renal, spermatic (ovarian in the female), common iliac, and superior vesical, arteries.

The **veins** terminate in the vessels corresponding to these arteries.

Lymphatics.—These pass to the *median group* of *lumbar glands*, and to the *internal iliac glands*.

Nerves.—These accompany the arteries, and are derived from the renal, spermatic (ovarian in the female), and pelvic, plexuses. The fibres form plexuses in the fibrous and muscular coats, which contain small ganglia.

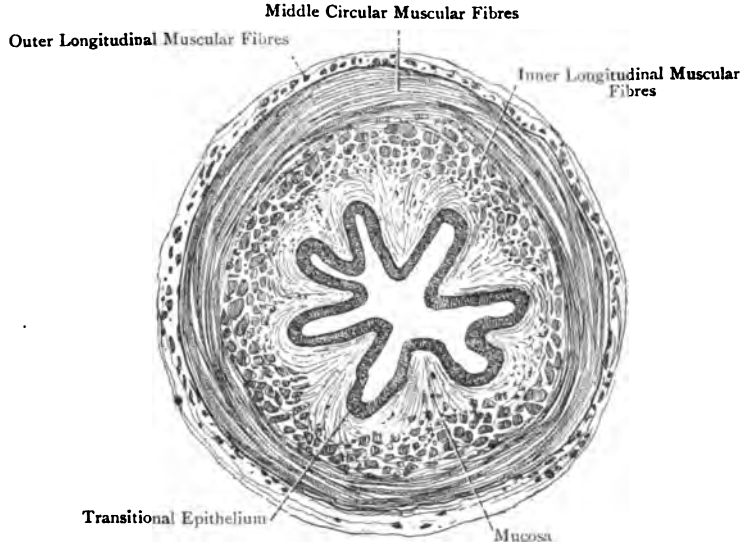


FIG. 348.—TRANSVERSE SECTION OF THE LOWER PART OF THE URETER, SHOWING ITS MINUTE STRUCTURE.

Structure of the Pelvis and Calices.—The structure of these parts of the excretory apparatus resembles that of the ureter, with the exception that they have only two layers of plain muscular tissue, instead of three as in the ureter. The layer which is wanting is the *outer longitudinal layer*. The calices are attached to the bases of the papillæ, and in these situations their fibrous coats become continuous with that part of the fibrous capsule of the kidney which is prolonged inwards through the hilum to line the sinus. The internal longitudinal muscular fibres disappear towards the papilla, but the circular muscular fibres accompany a calix to its termination, where they are arranged in the form of a circular band, which surrounds the base of a papilla at the line of attachment of a calix. The stratified transitional epithelium of the mucous coat of a calix is prolonged over the apex of each papilla.

Stroma of the Kidneys.—Between the uriniferous tubules and bloodvessels there is a certain amount of connective tissue, which is present in greatest abundance in the region of the papillary zones.

This constitutes what is known as the **fibrous** or **interstitial stroma,** of which there is a very small amount.

Early Condition of the Kidneys.—The kidneys of a child at the period of birth are lobulated, each lobule representing a Malpighian pyramid surrounded by cortical substance. In this respect they resemble the permanently lobulated kidneys of certain animals, *e.g.*, the ox. The lobules first become apparent towards the end of the third month of intra-uterine life, and all traces of them have usually disappeared by the eighth or tenth year. They may, however, remain persistent to a greater or less extent throughout life, though this condition is of very rare occurrence. It is, however, not uncommon to find the surface of an adult kidney marked by faint grooves indicative of its original lobulated condition. The disappearance of the lobulated condition is brought about by the adjacent lobules coalescing, this being accompanied by an increased development of cortical substance at the surface. The portions of cortical substance which remain in the spaces between the medullary pyramids (except their apical parts) represent the septula renum or columnæ Bertini.

Development of the Kidneys.—The kidneys belong to the uro-genital system, and are usually regarded as of mesoblastic origin. Each is developed in connection with a portion of mesoblast which is situated between the paraxial mesoblast and the pleuro-peritoneal cavity, and is known as the **intermediate cell-mass.**

First Stage.—In the very early embryo, from the second to the third week, a longitudinal cord makes its appearance, which is formed by a segmentation of mesoblastic cells from the intermediate cell-mass. This cord is at first solid, and is in close proximity to the epiblast, from which circumstance it is regarded by some authorities as being developed from the epiblast. It soon, however, acquires a lumen, and is then known as the **Wolffian duct.** Each Wolffian duct as it passes backwards lies within a fold of peritoneum, called the *uro-genital fold*, and the two ducts as they pass to the cloaca become embedded in a fold of connective tissue, called the *genital cord.* The posterior or caudal end of this duct opens into the posteror (lower) portion of the ventral or uro-genital compartment of the *cloaca*, which is the common opening of the uro-genital ducts and hind gut. The anterior or cephalic end of the Wolffian duct becomes attached to involutions of the peritoneal epithelium, between which tufts of capillary bloodvessels project into the peritoneal cavity. These capillary tufts form the **fore-kidney** or **pronephros,** which has only a temporary existence.

Second Stage.—This consists in the formation of the **mid-kidney, mesonephros,** or **Wolffian body.** This body takes the form of a number of tubes, called *segmental tubes*, which are developed in the mesoblast of the intermediate cell-mass, these tubes being transversely disposed at right angles to the Wolffian duct. They are at first solid, but each is subsequently provided with a lumen. By one extremity they open into the Wolffian duct, their other extremities being blind. These cæcal extremities, becoming enlarged, are invaginated, and each contains a tuft of capillary vessels. The Wolffian body attains its greatest development about the eighth week. As the permanent kidney becomes formed the Wolffian body begins to disappear, and it does so to a greater extent in the female than in the male. In the female vestiges of it are found in the parovarium or epoöphoron and the paroöphoron. In the male it gives rise to the tubuli recti of the testis, the tubes of the rete testis, the vasa efferentia, the coni vaculosi, the vas aberrans of Haller, and the paradidymis, or organ of Giraldés.

Third Stage.—This consists in the development of the **hind-kidney, metanephros,** or **permanent kidney.** The ureter and permanent kidney originate as a diverticulum from the posterior or caudal end of the Wolffian duct, close to where it opens into the ventral or uro-genital compartment of the cloaca at about the fourth week. This diverticulum is continued forwards to the mesoblastic tissue of the intermediate cell-mass. The part of it adjoining the Wolffian duct represents the *ureter.* The distal portion, becoming enlarged

forms the *pelvis*, and this, dividing into branches, gives rise to the *calices* or *infundibula*. The whole of the *uriniferous tubules* are now developed as tubular branches from the calices, which branches go on subdividing in the mesoblastic tissue of the intermediate cell-mass. Ultimately the distal cæcal extremity of each tubule, becoming dilated, is invaginated to form a *capsule of Bowman*, within which there is enclosed a tuft of capillary bloodvessels, representing a *glomerulus* or *Malpighian corpuscle*. Whilst this is one view of the development of the permanent kidney, according to which the whole of the uriniferous tubules spring from the branching calices, another view held by certain authorities must be stated. According to this view the following parts of the permanent kidney are developed from the ureteric diverticulum from the posterior part of the Wolffian duct, namely, the ureter, pelvis, calices, and collecting-tubes; whereas the convoluted tubules and Malpighian corpuscles are developed in the mesoblastic tissue of the intermediate cell-mass, and subsequently become connected with the branchings of the calices. At a later period the ureter becomes detached from the Wolffian duct, and opens into the anterior part of the ventral or uro-genital compartment of the cloaca. In the female the remains of the Wolffian duct are represented by the principal tube of the parovarium or epoöphoron, and the hydatids of Morgagni which are sometimes met with near the corpus fimbriatum of the Fallopian tube. In the male the Wolffian duct forms more important permanent structures, namely, the epididymis, the vas deferens, and the common ejaculatory duct, the vesicula seminalis being a diverticulum from the lower part of the latter.

The interstitial stroma of the kidney is developed from the mesoblastic connective tissue of the intermediate cell-mass.

THE PELVIS.

The pelvis is the lower division of the abdomen which lies below the level of the ilio-pectineal lines and sacral promontory. Unlike the abdomen proper the walls of the pelvis are chiefly osseous. The posterior wall is constructed by the sacrum and coccyx, with the origins of the pyriformes muscles. Each lateral wall is formed by the body and spine of the ischium, and is covered by the obturator internus muscle. The anterior wall is formed by the bodies of the pubic bones which, in the median line, construct the symphysis pubis. Between the posterior wall and each lateral wall is the large sacro-sciatic space, which is partly closed by the powerful great and small sacro-sciatic ligaments. This space is divided into two parts by the small sacro-sciatic ligament and the spine of the ischium. The upper part forms the great sacro-sciatic foramen, which transmits the pyriformis muscle, the gluteal vessels and nerves, the sciatic vessels and nerves, the internal pudic vessels and pudic nerve, the nerve to the obturator internus and gemellus superior, and the nerve to the quadratus femoris and gemellus inferior. The lower part forms the small sacro-sciatic foramen, which transmits the obturator internus muscle and its nerve, the internal pudic vessels, and the pudic nerve. At each lateral part of the anterior wall is the obturator foramen, which is closed, except superiorly, by the obturator membrane, covered by the obturator internus muscle. Below the symphysis pubis is the subpubic arch, which is occupied by the triangular ligament of the urethra. The

pelvic wall, thus constructed, is clothed by the pelvic fascia. Superiorly the pelvic cavity is quite open and in free communication with the abdomen proper. Inferiorly it is for the most part closed, a complex septum separating it from the perineum underneath. This septum is partly muscular and partly fascial. The muscles entering into it are the levatores ani and the coccygei, which construct the pelvic diaphragm. The fascial element is formed on either side by the visceral pelvic fascia, which clothes the superior or pelvic surface of the muscular diaphragm, and the anal fascia, which covers its inferior or perineal surface. The floor of the pelvis is consequently movable, being capable of ascending and descending. It affords passage to the rectum, and, in addition, to the vagina in the female.

Contents of the Pelvis.—The contents of the **male pelvis** are as follows: the pelvic colon and rectum; the bladder, with the lower portions of the ureters and the prostate gland, the latter containing the prostatic part of the urethra; the vesiculæ seminales and the lower portions of the vasa deferentia; the internal iliac vessels and their branches; portions of the superior hemorrhoidal and middle sacral vessels; the hemorrhoidal, vesical, and prostatic venous plexuses, the latter receiving the dorsal vein of the penis in two divisions; the sacral and sacro-coccygeal plexuses and their branches; the pelvic portions of the gangliated sympathetic chains; and the obturator nerves in part of their course.

The differences in the contents of the **female pelvis,** as compared with those of the male, are as follows:

For the prostate gland and prostatic portion of the urethra substitute the female urethra, uterus, and vagina. For the vesiculæ seminales and portions of the vasa deferentia substitute the broad ligaments of the uterus and their contents, namely, the Fallopian tubes, the ovaries with their ligaments, and the round ligaments of the uterus. Add to portions of the superior hemorrhoidal and middle sacral vessels portions of the ovarian vessels. For the prostatic venous plexus substitute the pudendal plexus, and add the uterine and ovarian venous plexuses.

The Male Pelvis.

General Position of the Viscera.—The pelvic colon and rectum are situated upon the posterior wall, the pelvic colon reaching as low as the third sacral vertebra, and the rectum extending thence downwards and forwards to the interval between the levatores ani muscles, where it is succeeded by the anal canal. The bladder is anterior in position, being situated behind the bodies of the pubic bones, and resting by its base upon the rectum. The vesiculæ seminales and the lower portions of the vasa deferentia lie in contact with the base of the bladder, between it and the rectum. The prostate gland surrounds the neck of the bladder and the prostatic part of the urethra.

Peritoneum.—The disposition of the peritoneum will be simplified

by defining the limits of the pelvic colon and rectum, and the different parts of the bladder. The **pelvic colon** extends from the inner border of the left psoas magnus, just anterior to the left sacro-iliac articulation, to the level of the third sacral vertebra. The **rectum** extends from the third sacral vertebra to a point 1½ inches in front of and below the tip of the coccyx, where it pierces the pelvic diaphragm to terminate in the anal canal, which is the part of the large gut surrounded by the sphincter muscles. The **bladder,** when empty, or only moderately distended, presents the following parts: (1) an apex, which is directed forwards, and lies behind the upper part of the symphysis pubis, where it has connected with it the fibrous cord representing the urachus; (2) a

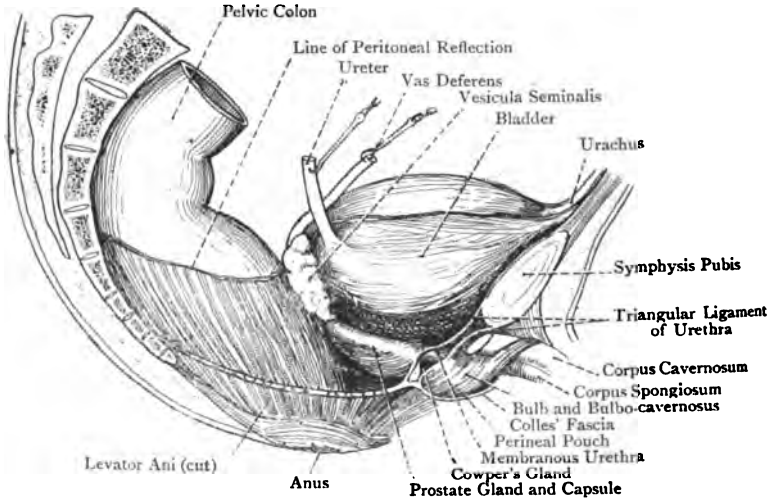


FIG. 349.—THE VISCERA OF THE MALE PELVIS (LATERAL VIEW).

base or fundus, directed backwards and downwards towards the rectum, from which it is separated by the vesiculæ seminales and vasa deferentia; (3) a body, which has a superior surface, an inferior surface, and three borders, two being lateral and one posterior; and (4) a neck.

The peritoneum, having descended from the posterior wall of the abdomen over the common iliac vessels, enters the back part of the pelvic cavity, where it invests the pelvic colon, forming behind it an expanded, wavy mesentery, called the *pelvic meso-colon*, which attaches it to the front of the sacrum as low as the third sacral vertebra. The peritoneum is then prolonged upon the rectum, the **upper third** of which it covers *anteriorly* and *laterally*, but not posteriorly, the **middle third** being covered by it only *anteriorly*, whilst the **lower third** is destitute of peritoneal covering.

The point at which the peritoneum leaves the rectum is fully 3 inches above the anus. The membrane is now carried forwards to the upper ends of the vesiculæ seminales, and the adjacent portions of the vasa deferentia, which it covers. Thereafter it passes forwards over the superior surface of the bladder, which it completely covers as far as the apex. Here it meets with the urachus, and by this it is conducted from the bladder to the posterior surface of the anterior abdominal wall. Along each lateral border of the bladder the peritoneum is reflected over the corresponding lateral wall of the pelvis. In passing from the rectum to the upper part of the base of the bladder, the peritoneum forms the **recto-vesical pouch.** The bottom of this pouch is, as a rule, fully 1 inch distant from the base of the prostate gland, thus leaving the part of the base of the bladder, called the external trigone, quite free from peritoneum. The peritoneum, as it passes to and from the bladder, forms certain folds, which constitute the **false ligaments** of the viscus. These are five in number, as follows: *two posterior*, which represent the laterally-disposed lips of the mouth of the recto-vesical pouch; *two lateral*, right and left, which represent the reflection of peritoneum from each lateral border of the bladder to the corresponding lateral wall of the pelvis; and *superior*, which is the reflection of the peritoneum from the apex of the bladder to the posterior surface of the anterior abdominal wall along the urachus. The parts of the bladder which are left uncovered by peritoneum are (1) the inferior surface, and (2) the external trigone.

The pelvic peritoneum on either side of the bladder and rectum presents three fossæ when these viscera are empty, which are named, from before backwards, *paravesical*, *paravesicular*, and *pararectal*.

Retro-pubic Pad of Fat.—This is a collection of areolar and adipose tissues which lies between the posterior aspect of the bodies of the pubic bones, the bladder, and the pubo-prostatic ligaments.

Pelvic Fascia.—This fascia clothes the inner wall of the pelvis, and furnishes inward expansions, which have an intricate connection with, and serve to support, the contained viscera. It is divisible into two portions—parietal and visceral.

Parietal Portion.—Over the posterior wall of the pelvic cavity the parietal portion of the pelvic fascia, which is here very thin, covers the intrapelvic portion of each pyriformis muscle and the corresponding sacral plexus, this portion being known as the *fascia of the pyriformis*. Over the lateral wall the fascia attains considerable strength, and is attached superiorly to the back part of the iliac portion of the ilio-pectineal line for a short distance, where it becomes continuous with the iliac fascia. In front of this the fascia falls short of the ilio-pectineal line, and is fixed to the lateral wall of the pelvis a little below the line, its attachment being oblique, and accurately following the upper border of the obturator internus muscle. When it arrives at the upper part of

the obturator foramen, there is a break in the osseous attachment of the fascia, which here joins the upper border of the obturator membrane over the upper border of the obturator internus, and so converts the obturator groove into a canal for the passage of the obturator vessels and nerve. At the upper and inner part of the obturator foramen the fascia resumes its osseous attachment, but falls more and more short of the pelvic margin, its connection with the back of the body of the os pubis being in a direction downwards and inwards till it reaches a point just below the lower part of the symphysis pubis. The fascia descends from the foregoing line of attachment, closely covering the obturator internus, to be

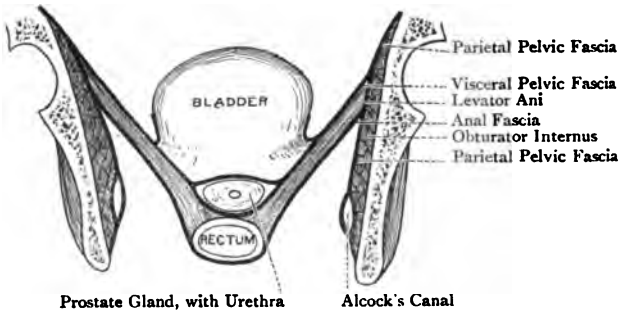


FIG. 350.—THE PELVIC FASCIA (ANTERIOR VIEW).

attached as follows from before backwards : (1) to the pelvic aspect of the ischio-pubic ramus near the subpubic arch, where it lies on the mesial side of the obturator internus ; (2) to the inner margin of the falciform process of the great sacro-sciatic ligament at the lower part of the ischial ramus, and also to the great sacro-sciatic ligament itself, where that is attached to the inner margin of the tuber ischii ; and (3) to a portion of the great sacro-sciatic ligament near its ischial attachment, and to the anterior margin of the great sciatic notch. The lateral portion of the parietal pelvic fascia, from its relation to the obturator internus muscle, is sometimes called the *obturator fascia*. From its lower attachment the fascia is continued backwards and inwards over the great sacro-sciatic foramen, pyriformis, and sacral plexus to the sacrum, as the fascia of the pyriformis. As it covers the foramen it is perforated by the gluteal, sciatic, and internal pudic vessels.

At the anterior part of the pelvic cavity the fascia, after taking attachment to the pelvic surface of the ischio-pubic ramus near the subpubic arch, is continued inwards over that arch, where it lies behind the compressor urethræ muscle, and forms one half of the postero-superior or deep layer of the triangular ligament, the other half being formed by the corresponding portion of the fascia of the opposite side. When it arrives at the urethra, it changes its course, and passes backwards over the anterior border of the

levator ani to blend with that portion of the visceral pelvic fascia which ensheathes the prostate gland.

In the direction of a line passing from the inner aspect of the ischial spine to the back of the body of the os pubis, near its lower end and close to the symphysis, the lateral pelvic fascia is strengthened by fibres which impart to it a white colour. This part is called the **white line,** and it serves to divide the fascia into two portions, upper or pelvic proper, and lower or perineal. The *pelvic portion* looks into the pelvic cavity, and covers the upper part of the obturator internus, whilst it is itself covered by the peritoneum. The *perineal portion* covers the lower part of the obturator internus, and lies on the outer wall of the ischio-rectal fossa, where it constructs Alcock's canal. The under aspect of the white line affords extensive origin to the levator ani muscle.

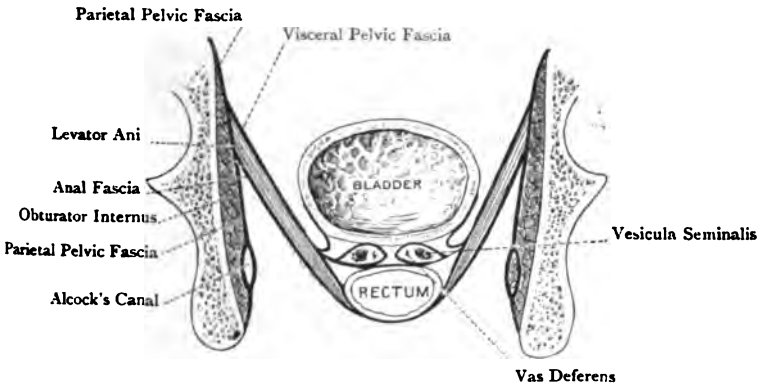


FIG. 351.—DIAGRAM OF THE PELVIC FASCIA FROM BEHIND.

Visceral Portion of the Pelvic Fascia.—The visceral portion is destined to support the lower part of the bladder, vesiculæ seminales, terminal portions of the vasa deferentia, prostate gland, and rectum. It is a laminar offshoot of the parietal portion, from which it springs along the white line. Though, however, this is its principal source, it has an independent origin anteriorly on either side of the middle line from the posterior aspect of the body of the os pubis near the lower part of the symphysis. In this latter situation it lies a little above the attachment of the parietal portion, the anterior fibres of the levator ani taking origin from the portion of bone between the two fasciæ. Though the visceral portion forms one continuous sheet along its pelvic attachment, its ultimate disposition is so intricate that it is convenient to consider its arrangement under three divisions.

1. *Opposite the bladder, vesicula seminalis, and rectum.* In this region the visceral portion of the fascia passes inwards as far as the outer border of the vesicula seminalis. In doing so it covers

the upper surfaces of the levator ani and coccygeus, and is in turn covered by the peritoneum. At the outer border of the vesicula seminalis it divides into three laminæ—upper, middle, and lower. The **upper** or **vesical lamina** ascends upon the lateral aspect of the bladder for a short distance, and ultimately loses itself in the muscular tissue of the vesical wall. This portion at each side forms the lateral true ligament of the bladder. The **middle** or **recto-vesical lamina** passes inwards between the base of the bladder and the rectum, and is continuous with the corresponding lamina of the opposite side. As it passes inwards it furnishes a sheath to the vesicula seminalis and adjacent portion of the vas deferens, closely strapping these structures to the base of the bladder. The **lower** or **rectal lamina** descends upon the side of the rectum, and passes to its posterior surface, where it is continuous with the rectal lamina of the opposite side.

2. *Opposite the neck of the bladder and prostate gland.* In this situation the visceral portion of the fascia also divides into three laminæ—upper, middle, and lower. The **upper** or **prostatic lamina** passes inwards over the anterior surface of the prostate gland, and is continuous with the prostatic lamina of the opposite side. The **middle** or **recto-prostatic lamina** passes inwards between the posterior surface of the prostate gland and the rectum, and is continuous with the corresponding lamina of the opposite side. The **lower** or **rectal lamina** is unaltered in its disposition. The upper or prostatic and middle or recto-prostatic laminæ furnish a stout sheath to the prostate gland.

3. *Between the pubic bodies and the upper aspect of the neck of the bladder.* The portion of the visceral fascia in this region represents the upper lamina in the other regions, and may be called the **pubo-prostatico-vesical lamina.** It is arranged in the form of two stout cords, which are known as the *pubo-prostatic ligaments* or the *anterior true ligaments* of the bladder. Each is attached anteriorly to the posterior aspect of the body of the os pubis, near the lower part of the symphysis, and a little above the attachment of the parietal portion of the pelvic fascia in this region, the anterior fibres of the levator ani taking origin from the portion of bone between the two fasciæ. As the cord-like fascial bands pass backwards they are connected by a portion of the visceral fascia which covers the dorsal vein of the penis and lies deeply, thus giving rise to a small pouch, which is capable of admitting the point of a finger. This pouch is filled with fat, which is continuous with the retro-pubic pad of fat. The anterior portion of the visceral fascia lies upon the anterior surface of the prostate gland, and on reaching the neck of the bladder it passes forwards to its inferior surface, where it soon disappears in the muscular tissue of the vesical wall. The pubo-prostatic ligaments are largely composed of plain muscular tissue, which is derived from the longitudinal fibres on the inferior surface of the bladder as they pass to take attachment to the back of the bodies of the pubic bones on either

side of the middle line. These fibres constitute the so-called *pubo-vesical muscles*.

Anal Fascia.—This very thin sheet of fascia is an offshoot from the parietal pelvic fascia just below the white line and the origin of the levator ani. It closely covers the ischio-rectal surface of that muscle and of the coccygeus, upon which it descends to the region of the anus, where it blends with the aponeurotic investment of the sphincter ani externus.

Sympathetic Plexuses in the Pelvis.—These are derived from the **hypogastric plexus**, which is formed by the fusion of the two lateral strands of the aortic plexus after they have crossed the common iliac arteries. It is reinforced by branches from the ganglia of the lumbar sympathetic cords, and is situated in front of the body of the fifth lumbar vertebra between the common iliac vessels. It is a large, flattened plexus, measuring about 1½ inches in breadth, and it breaks up into two divisions, which form the **right** and **left pelvic plexuses.** Each of these enters the pelvis on the inner side of the internal iliac artery, and takes up a position on the side of the rectum. The pelvic plexus of each side is reinforced by branches from the upper one or two ganglia of the pelvic sympathetic chain, and by spinal fibres from the anterior primary divisions of the third and fourth sacral nerves (sometimes also the second), there being very small ganglia at the places of junction. From each plexus the following secondary plexuses are given off, which accompany the corresponding branches of the internal iliac artery: hemorrhoidal, vesical, prostatic, vesicular, and deferential, the latter three being replaced in the female by the vaginal and uterine plexuses.

Internal Iliac Artery.—This vessel arises from the common iliac opposite the lumbo-sacral articulation, and terminates opposite the upper border of the great sciatic notch by dividing into an anterior and a posterior division. The length of the vessel is about 1½ inches, and its direction is downwards and backwards.

Relations—*Anterior.*—The artery is covered by the peritoneum, and the ureter descends over it. The terminal part of the ileum forms an anterior relation of the right vessel, whilst the pelvic colon is similarly related to the left. *Posterior.*—The vessel rests chiefly upon its own vein, but near its origin it is placed over the commencement of the common iliac vein. Behind the veins there are the lumbo-sacral cord and ala of the sacrum. *External.*—The psoas magnus, with the intervention of the external iliac vein, and subsequently the lateral wall of the pelvis, with the intervention of the obturator nerve. *Internal.*—The peritoneum.

Varieties.—The chief variety affects the length of the vessel. It may be shorter or longer than usual, according as the common iliac is longer or shorter than normal, or according to the height at which the internal iliac ends in its two divisions.

Fœtal Condition.—During fœtal life the internal iliac is represented by the **hypogastric** and **umbilical arteries,** the size of which greatly exceeds that of the external iliac. The function of these arteries is to carry the impure blood

from the fœtus to the placenta of the mother. The hypogastric artery passes forwards to the posterior surface of the anterior wall of the abdomen, being crossed by the vas deferens. It then ascends to the lower part of the umbilicus, where it leaves the abdomen with its fellow. Beyond the umbilicus the hypogastric is known as the umbilical artery, and the two umbilical arteries, together with the umbilical vein, form the umbilical cord, in which the arteries describe spiral coils around the vein. The arteries convey the impure blood to the placenta, where it is purified, after which it is returned to the abdomen of the fœtus by the umbilical vein. After birth, there being no further use for the placental circulation, the umbilical cord is tied, and the child separated from the mother. Thereafter the hypogastric arteries become impervious, and each is converted into a fibrous cord. The obliteration, however, does not involve the first 1½ inches of the vessel, which persist as the internal iliac artery of the adult. Moreover, the proximal end of the fibrous cord representing the obliterated hypogastric remains pervious also, and, being connected with the anterior division of the internal iliac, it furnishes the superior vesical artery or arteries This pervious portion lies along the side of the pelvis beneath the peritoneum, where it is crossed by the vas deferens in the male, and the round ligament of the uterus in the female. The fœtal hypogastric artery gives off the sciatic, which is the primitive main artery of the lower limb, until the external iliac, which becomes the femoral, is developed.

Branches.—These are subject to much variation. In normal cases they arise from the two terminal divisions, anterior and posterior, some of them being parietal in their distribution, which will be indicated by the letter P, whilst others are visceral, which will be indicated by the letter V. The branches are as follows :

Anterior Division.		**Posterior Division.**
Visceral.	*Parietal.*	*Parietal.*
Superior vesical.	Obturator.	Ilio-lumbar.
Inferior vesical.	Internal pudic.	Lateral sacral.
Middle hemorrhoidal.	Sciatic.	Gluteal.

In the female the inferior vesical artery may be replaced by the vaginal, or the vaginal may be an independent branch, and the uterine artery is always a special branch.

Anterior Division.—The **superior vesical artery** (V) arises from the pervious portion of the fibrous cord which represents the fœtal hypogastric artery, and at once breaks up into several twigs which frequently have independent origins. They are distributed to the upper portion of the bladder, and anastomose with the vesical of the obturator, and the inferior vesical of the same side, and with the superior vesical of the opposite side. The superior vesical furnishes the following branches : *urachal* to the urachus ; *ureteric* to the lower end of the ureter ; and *deferential* (as a rule) to the vas deferens, though this branch may arise from the inferior vesical. The *deferential artery*, which is usually of small size, divides into a descending and an ascending branch. The descending branch passes downwards to supply the ampulla of the vas deferens, and the vesicula seminalis. The ascending branch accompanies the vas deferens through the internal abdominal ring and inguinal canal into the scrotum, supplying the vas deferens, and giving a few twigs

to the globus minor of the epididymis, in which latter situation it anastomoses with the epididymal branch of the spermatic artery. In the spermatic cord it also anastomoses with the cremasteric branch of the deep epigastric. The deferential artery is sometimes of large size, and then it takes the place of the spermatic artery, if that vessel should be absent. One of the branches of the superior vesical artery is sometimes spoken of as the middle vesical.

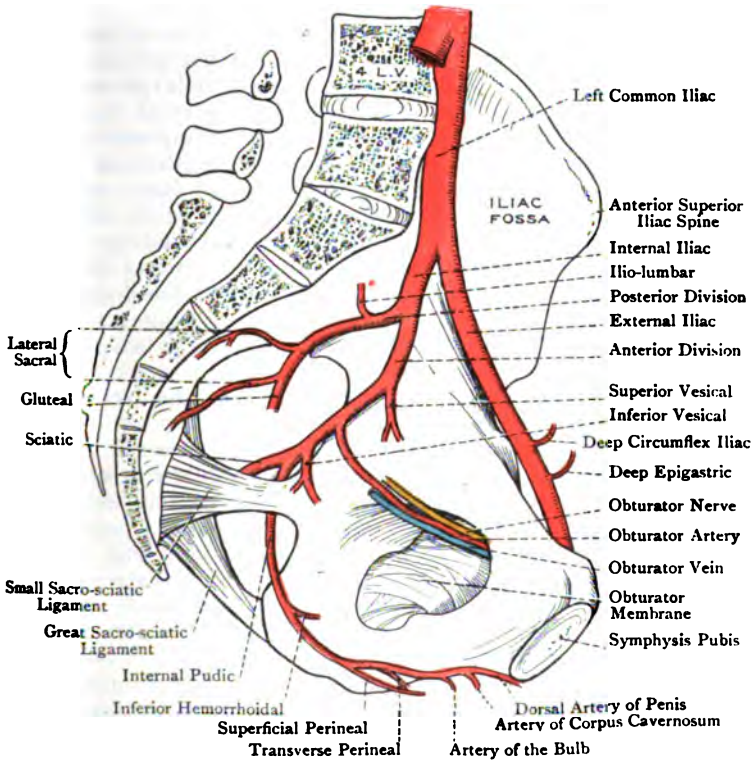


FIG. 352.—THE LEFT INTERNAL ILIAC ARTERY AND ITS BRANCHES.

The **inferior vesical artery** (V) takes an inward course to the lower portion of the bladder, which it supplies, giving branches to the vesicula seminalis, ampulla of the vas deferens, and prostate gland, and in the female to the vagina. It sometimes gives off the deferential artery, and it may give origin to an accessory pudic. It anastomoses with the superior vesical and middle hemorrhoidal of its own side, and with its fellow of the opposite side.

The **middle hemorrhoidal artery** (V) often arises in common with

the inferior vesical. It is distributed to the rectum, and gives branches to the vesicula seminalis, ampulla of the vas deferens, and prostate gland. The anastomoses which it establishes are with the superior hemorrhoidal of the inferior mesenteric, the inferior hemorrhoidal of the internal pudic, the inferior vesical of its own side, and its fellow of the opposite side.

The **obturator artery** (P) passes along the outer wall of the pelvic cavity on its way to the obturator canal, lying between the parietal pelvic fascia and the peritoneum. It has the obturator nerve above it, and its own vein below it. In entering the obturator canal, by which it emerges from the pelvis, the artery does not pierce the parietal pelvic fascia, but passes over its upper border, where that joins the upper part of the obturator membrane. As the artery passes along the pelvic wall it furnishes the following branches: *muscular* to the obturator internus; *iliac* to the iliac fossa, which supply the bone, psoas magnus, and iliacus, and anastomose with the iliac branch of the ilio-lumbar; *vesical*, which reaches the side of the bladder within the lateral false ligament; and *pubic* to the back of the body of the os pubis, where it anastomoses with the pubic branch of the deep epigastric from the external iliac, and its fellow of the opposite side.

For the distribution of the obturator artery outside the pelvis, see p. 461.

The obturator artery sometimes arises from the deep epigastric; see p. 436.

The **internal pudic artery** (P) is one of the terminal branches of the anterior division. It descends with the sciatic artery upon the pyriformis and sacral nerves, and emerges from the pelvis through the lower compartment of the great sacro-sciatic foramen, having previously pierced the parietal pelvic fascia. The intrapelvic branches of the vessel are unimportant, and are distributed to the pyriformis, coccygeus, obturator internus, and pelvic fascia. For the further course and distribution of the artery, see the gluteal region and the perineum, pp. 408 and 586.

The **sciatic artery** (P) is the other and larger terminal branch of the anterior division. It descends, usually behind the internal pudic, upon the pyriformis and sacral nerves, and emerges from the pelvis through the lower compartment of the great sacro-sciatic foramen, having previously pierced the parietal pelvic fascia. Within the pelvis the artery gives off branches to the pyriformis, levator ani, coccygeus, rectum, bladder, vesicula seminalis, and prostate gland.

For the extrapelvic course and distribution of the vessel, see p. 407.

Posterior Division.—The **ilio-lumbar artery** (P) passes upwards and outwards in front of the sacro-iliac articulation, between the lumbo-sacral cord and obturator nerve. In its course it passes behind the external iliac, or, it may be, the common iliac, vessels, and also behind the psoas magnus and iliacus. On reaching the back part

of the iliac fossa, it divides into two branches, iliac and lumbar, The *iliac branch*, passing transversely, ramifies in the iliacus and ilium, and anastomoses with the iliac branch of the obturator and branches of the deep circumflex iliac from the external iliac. The *lumbar branch* ascends beneath the psoas magnus on to the quadratus lumborum, where it anastomoses with the terminal part of the deep circumflex iliac, and the last lumbar of the abdominal aorta. In its course it furnishes a spinal branch, which enters the spinal canal through the intervertebral foramen between the fifth lumbar and first sacral vertebræ, to be distributed in a manner similar to the other spinal arteries.

The **lateral sacral arteries** (P) are usually two in number, superior and inferior. They course downwards and inwards to the front of the lateral mass of the sacrum, passing in front of the pyriformis and sacral nerves. Upon the sacrum both arteries lie external to the anterior sacral foramina, the superior being confined to the region of the first two foramina, whilst the inferior descends as low as the coccyx, where it anastomoses with the middle sacral artery. They are distributed to the pyriformis and sacral nerves, and furnish spinal branches, which enter the anterior sacral foramina, and so reach the sacral canal, where they supply its contents. Each spinal branch, before entering the sacral canal, gives off a posterior branch, which emerges through the posterior sacral foramen, and anastomoses with branches of the gluteal, sciatic, and internal pudic. The lateral sacral arteries anastomose with each other and with the middle sacral.

The **gluteal artery** (P) is a large vessel, which is the continuation of the posterior division. It is destined for the supply of the gluteal region, and lies within the pelvis for a very short distance. Its direction is backwards through the parietal pelvic fascia, and between the lumbo-sacral cord and the anterior primary division of the first sacral nerve, its escape from the pelvis being through the upper compartment of the great sacro-sciatic foramen. The branches of the artery within the pelvis are unimportant.

For the extrapelvic course and distribution of the vessel, see p. 405.

The branches of the internal iliac, with one exception, have to pierce the pelvic fascia. The exception is the **obturator artery,** which, as stated, passes over the upper border of the parietal pelvic fascia at the obturator foramen.

Internal Iliac Vein.—This vessel results from the union of branches which correspond, for the most part, with branches of the internal iliac artery. The ilio-lumbar vein, however, is an exception, inasmuch as it is a tributary of the common iliac vein. Moreover, during fœtal life the umbilical vein, which corresponds to the hypogastric (subsequently umbilical) artery, passes to the liver after entering the abdomen of the fœtus. The internal iliac vein extends from the upper part of the great sciatic notch to the sacro-

iliac articulation on a level with the pelvic brim, where it joins the external iliac, and so the common iliac vein is formed. In its course it lies behind the corresponding artery. There are no valves in the vein itself, but its branches are freely provided with them.

The internal iliac vein is developed from the lower part of the cardinal vein.

Internal Iliac Lymphatic Glands.—These lie along the course of the artery, and are about ten in number. They receive their afferent vessels from the following sources: the deep lymphatics of the gluteal region, the upper part of the back of the thigh, and the upper part of the inner side of the thigh, the deep lymphatics of the penis (or clitoris in the female), bladder, vesicula seminalis, vas deferens, prostate gland, prostatic portion of the urethra and adjacent part of the membranous portion, lower two-thirds of the uterus, and upper two-thirds of the vagina. The internal iliac glands also receive the deep lymphatics of the perineum and the lymphatics of the back part of the scrotum. Their efferent vessels pass to the *median lumbar glands* through the intervention of the so-called common iliac glands.

Anterior Primary Divisions of the Sacral and Coccygeal Nerves.—There are five sacral nerves and one coccygeal nerve on either side. The anterior primary divisions of the first four sacral nerves emerge into the pelvis through the anterior sacral foramina, and that of the fifth sacral passes between the inferior lateral angle of the sacrum and the transverse process of the first coccygeal vertebra, through the coccygeus muscle. The anterior primary division of the coccygeal nerve enters the pelvis below the transverse process of the first coccygeal vertebra, through the coccygeus muscle. The first and second sacral nerves are of large size, and their course is obliquely downwards and outwards. Beyond the second they diminish rapidly in size, and pass more horizontally. They receive grey rami communicantes from the adjacent ganglia of the pelvic sympathetic cord, and the third and fourth nerves (sometimes also the second) furnish white rami communicantes to the corresponding pelvic plexus. The anterior primary divisions of the first and second sacral nerves divide each into an anterior or ventral and a posterior or dorsal branch. The anterior primary division of the third sacral nerve divides into an upper and a lower branch, and is known as the *nervus bigeminus*. The anterior primary division of the fourth sacral nerve also divides into an upper and a lower branch, and it is known as a *nervus furcalis*. The lumbo-sacral cord in two divisions, ventral and dorsal, the anterior primary divisions of the first two sacral nerves, the upper and lower branches of the third sacral, and the small upper branch of the fourth sacral form the sacral plexus, whilst the large lower branch of the fourth sacral, the fifth sacral, and the coccygeal form the sacro-coccygeal plexus:

Sacral Plexus.—This plexus, formed as stated, is a large flattened

mass, lying upon the pyriformis muscle, and behind the parietal pelvic fascia, which separates it from the sciatic and pudic vessels. The mass ultimately forms two bands, upper and lower. The **upper** or **sciatic band,** which is the larger of the two, receives the lumbo-sacral cord, first sacral, larger portion of the second sacral, and upper branch of the third sacral nerves. It is flat and somewhat triangular, and is continued into the great sciatic nerve, which leaves the pelvis through the lower part of the great sacro-sciatic

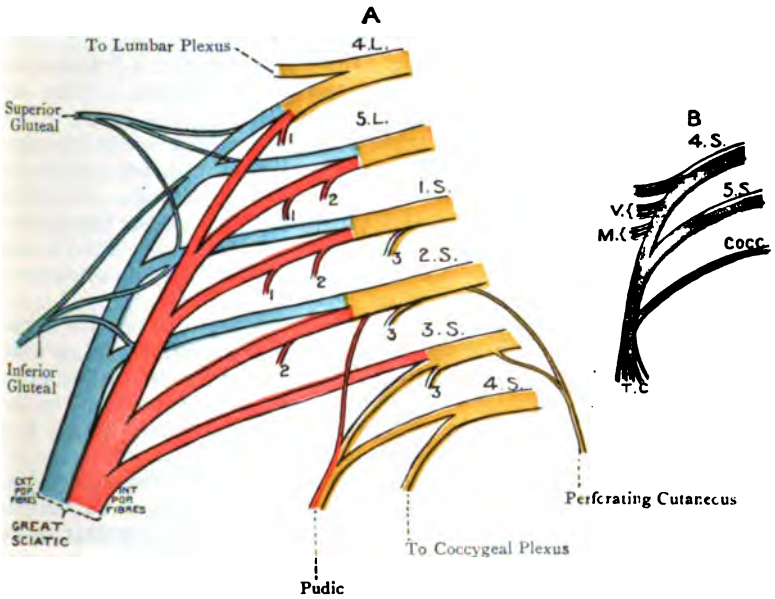


FIG. 353.—**A**, THE SACRAL PLEXUS; **B**, THE SACRO-COCCYGEAL PLEXUS.

A

1, 1, 1. Nerve to Quadratus Femoris
2, 2, 2. Nerve to Obturator Internus
3, 3, 3. Small Sciatic Nerve

B

4.S. Fourth Sacral, giving a Branch to Sacral Plexus
V. Visceral Branches
M. Muscular Branches
T.C. Terminal Cutaneous Branches

foramen below the pyriformis, without piercing the parietal pelvic fascia. The upper band and its contributory nerves are sometimes spoken of as the *sciatic plexus*. The **lower** or **pudic band,** the smaller of the two, receives fibres from the second, lower branch of the third, and upper branch of the fourth sacral nerves, and is continued into the pudic nerve, which leaves the pelvis, like the great sciatic, through the lower compartment of the great sacro-sciatic foramen without piercing the parietal pelvic fascia. The lower band and its contributory nerves are sometimes spoken of as the *pudic plexus*. The great sciatic and pudic nerves are

thus the terminal branches of the sacral plexus. The reason of the name *nervus bigeminus*, as applied to the third sacral nerve, is because it enters into the sciatic band by its upper branch, and into the pudic band by its lower branch.

Branches.—The branches of the sacral plexus are arranged in two groups—collateral and terminal.

Collateral Group.—The branches of this group form three sets —visceral, muscular, and cutaneous.

Visceral Branches.—These are derived from the third sacral and that part of the fourth which enters into the sacral plexus (sometimes also from the second). They are white rami communicantes, which reinforce the pelvic plexus of the sympathetic, a few of them being traceable independently to the pelvic viscera. They are known as the **pelvic splanchnics.**

Muscular Branches.—The **superior gluteal nerve** arises by three roots from the dorsal divisions of the descending branch of the fourth lumbar, fifth lumbar, and first sacral nerves. It passes outwards and backwards, and leaves the pelvis with the gluteal artery through the upper compartment of the great sacro-sciatic foramen, to be distributed to the gluteus medius, gluteus minimus, and tensor fasciæ femoris muscles.

The **inferior gluteal nerve** arises by three roots from the dorsal divisions of the fifth lumbar and first and second sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, below the pyriformis and superficial to the great sciatic nerve, to be distributed to the gluteus maximus. It is usually intimately associated with the small sciatic nerve.

The **nerves to the pyriformis,** which are usually two in number, spring from the dorsal divisions of the first and second sacral nerves.

The **nerve to the obturator internus and gemellus superior** arises by three roots from the ventral divisions of the fifth lumbar and first and second sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, crosses the back of the ischial spine, where it lies external to the internal pudic vessels, and then passes through the small sacro-sciatic foramen to the outer wall of the ischio-rectal fossa, where it enters the inner or pelvic surface of the obturator internus. In the gluteal region it gives a branch to the gemellus superior when that muscle is present.

The **nerve to the quadratus femoris and gemellus inferior** arises by three roots from the ventral divisions of the descending branch of the fourth lumbar, fifth lumbar, and first sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, and then lies between the ischium and the great sciatic nerve. It subsequently descends over the back of the capsular ligament of the hip-joint, to which it usually gives a branch, and beneath the gemelli and obturator internus to the deep surface of the quadratus femoris, in which it ends, having previously given a branch to the gemellus inferior.

Cutaneous Branches.—The **small sciatic nerve** arises by three roots from the posterior aspects of the first, second, and third sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, and is distributed to (1) the lower and outer part of the gluteal region by its gluteal cutaneous branches, (2) the integument of the scrotum by the long pudendal nerve of Soemmering, (3) the integument of the back of the thigh, and (4) the integument of the back of the leg as low as about the centre of the calf.

The **perforating cutaneous nerve** arises by two roots from the posterior aspects of the second and third sacral nerves. It passes backwards through the great sacro-sciatic ligament, after which it turns round the lower border of the gluteus maximus near the coccyx to be distributed to the integument over the lower and inner part of that muscle.

Terminal Group.—This group is comprised of two nerves, namely, the great sciatic and the pudic.

The **great sciatic nerve** is the continuation of the upper or sciatic band of the sacral plexus. In reality it is made up of the two divisions in which it ultimately ends, namely, the external and internal popliteal, which lie close together within the same sheath. Sometimes, however, these two divisions arise separately from the sacral plexus, in which cases the external popliteal nerve may pass through the pyriformis. Again, though the great sciatic nerve may be apparently single, a careful dissection of it, after the removal of its sheath, will reveal the external and internal popliteal nerves, which can be shown to have independent origins. The **external popliteal nerve** derives its fibres from the *dorsal* divisions of the descending branch of the fourth lumbar, fifth lumbar, and first and second sacral nerves; and the **internal popliteal nerve** derives its fibres from the *ventral* divisions of the foregoing nerves, and in addition from the upper branch of the third sacral.

The great sciatic nerve leaves the pelvis through the lower compartment of the great sacro-sciatic foramen below the pyriformis.

The **pudic nerve** is the continuation of the lower or pudic band of the sacral plexus. It arises by three roots from the ventral division of the second, the lower branch of the third, and the upper branch of the fourth sacral, the root from the third being the largest. The nerve leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, crosses the back of the ischial spine, where it lies internal to the internal pudic vessels, passes through the small sacro-sciatic foramen, and then traverses the outer wall of the ischio-rectal fossa. Having given off the inferior hemorrhoidal nerve, it divides into the perineal and dorsalis penis nerves, which with the internal pudic vessels are contained in Alcock's canal.

The sacral plexus and its branches being situated behind the parietal pelvic fascia, the branches do not pierce that fascia as they leave the pelvis. The branches of the internal iliac artery, on the

other hand, being placed on the superficial surface of the parietal pelvic fascia, have to pierce it, with the single exception of the *obturator artery*.

Sacro-coccygeal Plexus.—The nerves which form this plexus are the lower branch of the anterior primary division of the fourth sacral, the anterior primary division of the fifth sacral, and the anterior primary division of the coccygeal nerve. The upper branch of the fourth sacral enters the pudic band of the sacral plexus, and the fourth sacral is therefore a *nervus furcalis*, inasmuch as it gives a branch to the sacral plexus and one to the sacro-coccygeal plexus. Before entering the sacro-coccygeal plexus the lower branch of the fourth sacral nerve gives off visceral and muscular branches. The *visceral branches* for the most part reinforce the pelvic plexus of the sympathetic as white rami communicantes, but a few of them pass independently to the pelvic viscera. The *muscular branches* supply the levator ani, coccygeus, and sphincter ani externus. The branch to the latter muscle reaches the perineum either by piercing the coccygeus, or by passing between it and the levator ani, and, besides supplying the external sphincter, it gives branches to the integument between the coccyx and the anus. The nerve is known as the *hemorrhoidal* or *perineal branch of the fourth sacral*. The lower branch of the fourth sacral nerve, having parted with the foregoing offsets, descends upon the coccygeus where it joins the fifth sacral, which has just entered the pelvis through that muscle. The conjoined nerve now descends, and is soon reinforced by the coccygeal nerve, which also enters the pelvis by piercing the coccygeus. In this manner the sacro-coccygeal plexus is formed. It lies at the lower part of the posterior wall of the pelvis upon the coccygeus, and the nervous loop takes a downward course. Subsequently it divides into several twigs, which leave the pelvis by piercing the coccygeus, the small sacro-sciatic ligament, and the adjacent portion of the gluteus maximus to be distributed to the integument over the coccyx.

Ureters.—The ureter of each side, having crossed the termination of the common iliac, or the commencement of the external iliac, artery, enters the pelvis. It then passes downwards and forwards in front of the internal iliac artery to the outer wall of the pelvis, lying beneath the peritoneum, and crossing internally the obturator vessels and nerve, and the obliterated hypogastric artery. It subsequently passes inwards to the bladder, being crossed internally by the vas deferens. Having arrived at the lateral or ureteric angle of the bladder, it passes obliquely through the vesical wall anterior to the upper free end of the vesicula seminalis, being here about 2 inches distant from its fellow, and about 1½ inches from the base of the prostate gland.

Bladder.—The bladder, when empty, or only moderately distended, lies entirely within the cavity of the pelvis. When, however, it is fully distended, the apical part of the viscus rises above the level of the symphysis pubis into the hypogastric region of

the abdomen for at least 2 inches, and, in cases of marked over-distension, it may reach to the umbilicus, or even higher. The bladder, therefore, has to be considered under two aspects, namely, when empty, or only moderately distended, and when fully distended.

The bladder, *when empty*, or *moderately distended*, is triangular, and presents the following component parts : an apex, a base, and a body, the latter presenting a superior surface, an inferior surface, two lateral borders, a posterior border, two lateral angles, and a neck.

The *apex* is directed forwards, and lies behind the upper part of the symphysis pubis. It has connected with it the fibrous cord representing the *urachus*, which ascends on the posterior surface of the anterior abdominal wall to the lower part of the umbilicus. The *base* or *fundus* is directed backwards and downwards towards the rectum, from which it is separated by the

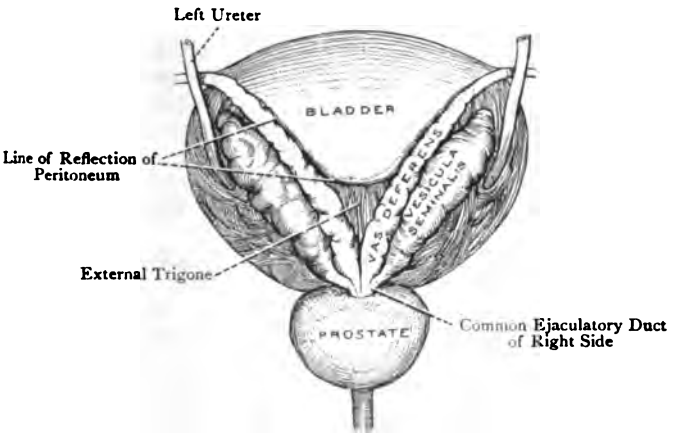


FIG. 354.—DISSECTION OF THE BASE OF THE BLADDER, SHOWING THE VESICULÆ SEMINALES, VASA DEFERENTIA, AND EXTERNAL TRIGONE.

vesiculæ seminales and terminal portions of the vasa deferentia, and the recto-vesical lamina of the visceral portion of the pelvic fascia. The base is separated from the superior surface by the posterior border, and from each rounded half of the inferior surface by a slight elevation, which extends from the lateral or ureteric angle of either side to the urethral opening. The *superior surface* is three-sided and slightly convex. It is usually related to a few coils of the small intestine, and a loop or two of the pelvic colon. The *inferior surface*, which is convex, rests upon (1) the symphysis pubis and the adjacent portions of the posterior surfaces of the bodies of the pubic bones, (2) the retro-pubic pad of fat, (3) the pubo-prostatic ligaments, and (4) the prostate gland. This surface, being rounded, is somewhat indefinitely divided into two lateral

portions. The *lateral borders* start from the apex, whence they pass backwards in a diverging manner, and each marks the separation between the superior surface and the corresponding half of the inferior surface. Posteriorly each lateral border meets the posterior border. The *posterior border* extends transversely between the superior surface and the base. At either end it is joined by the lateral border. The *lateral* or *ureteric angles* are situated on either side at the junction of the lateral with the posterior border. At these angles the ureters pass through the vesical wall. The *neck* is situated at the meeting of the base and inferior surface. It is surrounded by the base of the prostate gland, and it is in this situation where the vesical cavity becomes continuous with the urethra. The neck lies fully 2 inches behind the symphysis pubis, being a little lower than its upper border, and it is practically fixed in position by the prostate gland and pubo-prostatic ligaments.

The **external trigone** is the name given to a limited triangular space upon the exterior of the base, which is bounded as follows: above, by the bottom of the recto-vesical pouch of peritoneum; laterally, by the ampulla of the vas deferens, external to which is the vesicula seminalis; and below, by the approximation of the common ejaculatory ducts at the base of the prostate gland. The length of the space from the apex below to the base above is, as a rule, fully 1 inch, but its breadth is limited by the encroachment upon it of the deferential ampullæ. There is no peritoneum over this region.

The bladder during distension, and *when fully distended.* As the bladder becomes distended the neck alters its position only to a very slight extent in a downward direction. The demarcations between the component parts of the viscus gradually disappear, and it becomes ovoid. The apex appears above the symphysis pubis, and, as the organ increases in size, the apex and the superior portion of the body ascend into the hypogastrium in such a manner as to strip off the parietal peritoneum from the back of the linea alba. In this way a portion of the original inferior surface, *devoid of peritoneum*, is brought into direct contact with the back of the linea alba, which is now also *free from peritoneal covering*. A distended bladder may, therefore, be punctured or opened through the linea alba above the symphysis pubis without doing any injury to the peritoneum. The bladder is now becoming spheroidal, and its long axis is directed downwards and backwards. The part which rises highest is not the original urachal apex, but that part of the superior surface which is immediately adjacent to, and behind, the apex.

Peritoneal Relations.—The only part of the bladder which is covered by peritoneum is the superior surface. The peritoneum is reflected from the apex along the urachus, and at either side it leaves the organ along the lateral border. When the bladder is distended the lateral reflection of peritoneum appears to take place along the course of the obliterated hypogastric artery, but this

is due to the lateral distension and elevation of the viscus, the obliterated hypogastric itself lying along the outer wall of the pelvis. For the structure and development of the bladder, see pp. 810, 815.

Vas Deferens in the Pelvis.—The vas deferens enters the abdomen through the internal abdominal ring, where it lies on the inner side of the other constituents of the spermatic cord. It then hooks round the outer side of the deep epigastric artery, and, having crossed the external iliac vessels from without inwards, it dips down on the inner side of the external iliac vein. In this way it enters the pelvis under cover of the peritoneum. It now passes backwards and downwards upon the lateral wall, crossing the obliterated hypogastric artery and ureter, both on the inner side. Thereafter it is directed inwards to the inner aspect of the upper end of the vesicula seminalis, whence it passes downwards and inwards, and then vertically downwards upon the base of the bladder, where it lies close to the inner side of the seminal vesicle. This part of the vas deferens, which comes very near its fellow, is dilated and sacculated, like the adjacent vesicula seminalis, and is known as the **ampulla.** Close to the base of the prostate gland the sacculations disappear, and the duct, having become very narrow, is joined on the outer side at an acute angle by the duct of the seminal vesicle, and so the common ejaculatory duct is formed, which will be presently described. For the structure and development of the vas deferens, see pp. 630, 645.

Vesiculæ Seminales.—These are two in number, right and left, and lie between the base of the bladder and the rectum. They are sacculated reservoirs for the seminal fluid, and each is conical, being about 2 inches long, and about ½ inch broad at the widest part. The broad end is free, and looks upwards and outwards. It is covered posteriorly by the peritoneum which forms the recto-vesical pouch, and anterior to it is the ureter, as that is about to pass through the bladder. The upper ends of the two seminal vesicles are wide apart, and the bottom of the recto-vesical pouch descends between them for a short distance. The lower end of each, which is narrow and free from sacculations, approaches its fellow, the vasa deferentia intervening. This lower end represents the duct, which, as stated, joins the vas deferens at an acute angle close to the base of the prostate gland, and so gives rise to the common ejaculatory duct. For the structure and development of the vesiculæ seminales, see p. 816.

Common Ejaculatory Ducts.—These are two in number, right and left. Each is formed by the union of the duct of the vesicula seminalis with the vas deferens close to the base of the prostate gland, and it is about 1 inch in length. The two ducts pass downwards and inwards through the prostate gland, between the middle and lateral lobes, and each enters the lateral wall of the sinus pocularis. Thereafter each duct terminates in a minute aperture, which is situated either on the lateral margin of the opening of the

sinus pocularis, or immediately within the lateral margin. For the structure and development of the common ejaculatory ducts, see p. 817.

Prostate Gland.—This gland surrounds the neck of the bladder, as well as the first 1¼ inches of the urethra. It is firm in consistence, and in shape and colour resembles a chestnut—that is to say, it is conical and of a reddish-brown colour. It is subject to much variety in size, but its average measurements may be stated as follows: the transverse diameter at the base is about 1½ inches; the vertical diameter from base to apex is about 1¼ inches; and the antero-posterior diameter is about ¾ inch. The average weight of the organ is about 4½ drachms.

The gland is situated fully 1½ inches from the anus, and its anterior surface is about ½ inch behind the lower part of the symphysis pubis. It presents a base, an apex, a posterior or rectal surface, an anterior or pubic surface, and two lateral surfaces. The **base**, which is directed upwards, surrounds the neck of the bladder, and is intimately connected with the vesical wall. Notwithstanding this, however, there is a superficial line of demarcation between the two, which takes the form of an annular groove, occupied by a portion of the prostatic venous plexus. The common ejaculatory ducts enter the base close to the upper part of the posterior or rectal surface, where there is a small transverse cleft, called the *prostatic fissure*. The **apex** is directed downwards, and is the most dependent part of the organ. It is in contact with the postero-superior layer of the triangular ligament of the urethra. The **posterior** or **rectal surface** is flat and triangular. It is directed backwards and slightly downwards, and is set upon the anterior wall of the rectum, from which it is separated by the recto-prostatic lamina of the visceral portion of the pelvic fascia. This surface is accessible to manipulation on introducing the finger into the anal canal, and carrying it up for fully 1½ inches. The **anterior** or **pubic surface,** which is convex, is so much projected as to be really an anterior round border, which separates the two lateral surfaces. It lies about ½ inch behind the lower part of the symphysis pubis, from which it is separated by a portion of the prostatic venous plexus, the retro-pubic pad of fat, and the pubo-prostatic ligaments. The anterior surface projects between the anterior borders of the levatores ani muscles. The **lateral surfaces** are convex, and stand out in full relief. Each is embraced by the anterior fibres of the corresponding levator ani, which constitute the so-called levator prostatæ muscle. When an accessory pudic artery is present it passes over the lateral surface, and might be endangered in lateral lithotomy.

The gland is usually regarded as composed of three lobes, two lateral and a middle, but, though the middle lobe can usually be demarcated without much difficulty, there is no external indication of any separation between the lateral lobes. The **lateral lobes** form the chief bulk of the gland, and they meet and become con-

tinuous in front of and behind the prostatic portion of the urethra. The **middle lobe** represents that part of the basal portion of the gland which is wedged in between the common ejaculatory ducts and the adjacent portion of the neck of the bladder, and which lies just below the apex of the internal trigone. It is important to note that the middle lobe lies *behind* the commencement of the urethra. It is liable to become hypertrophied in old age, and then it may produce undue elevation of the uvula vesicæ in the interior of the bladder, which is a natural product of it. In this manner, by blocking the urethral orifice, it may not only give rise to difficulty in micturition, but may also obstruct catheterization.

The prostate gland is traversed by the first 1¼ inches of the urethra. The common ejaculatory ducts are also contained within the gland, in which they pass downwards and inwards between the middle and lateral lobes. For the structure and development of the prostate gland, see pp. 817 et seq.

Urethra.—The male urethra commences at the urethral orifice in the neck of the bladder, and terminates at the extremity of the

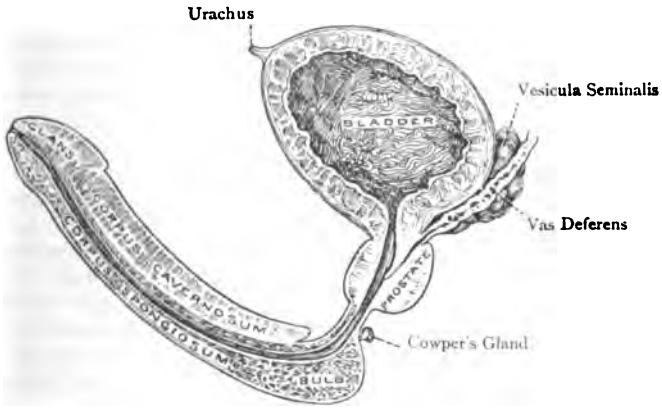


FIG. 355.—SECTION OF THE BLADDER AND PENIS TO SHOW THE URETHRA.

glans penis in a vertical fissure, called the **meatus urinarius.** It is about 8 inches in length, and is divided into three portions, which, from the bladder outwards, are called prostatic, membranous, and spongy. The prostatic and membranous portions constitute the *non-penile part* of the canal, and the spongy portion, being contained within the corpus spongiosum of the penis, represents the *penile part.*

The **prostatic portion of the urethra** is the part of the canal which is contained within the prostate gland. It is 1¼ inches in length, and its course is almost vertical, there being a slight curve with the concavity directed forwards. It is spindle-shaped, being wider at the centre than at either end, and at its upper or vesical

end it is rather wider than at the lower end. Its diameter at the centre, which is the widest part of the entire canal, is rather more than ½ inch; at the upper or vesical end it is rather less than this; and at the lower end it is still less. This portion of the urethra, though surrounded by the prostate gland, is the most dilatable part of the whole canal. Close to the neck of the bladder, however, it usually offers some resistance to the passage of an instrument. Its walls are anterior and posterior, the latter being often spoken of as the *floor*. These walls are in contact with each other, except during the passage of fluid, and the mucous membrane is thrown into longitudinal folds. The **posterior wall** presents along the middle line a prominent narrow elevation of the mucous membrane, called the **crest.** The other names by which is is known are *verumontanum, caput gallinaginis,* and *colliculus seminalis.* It is about ¾ inch long, and commences either a little below the urethral orifice of the bladder or at the lower end of the uvula vesicæ. As it descends it gradually becomes more prominent, assuming a height of about ⅛ inch, and then rapidly subsides. It is due to a thickening of the submucous tissue, which causes an elevation of the mucous membrane. On account of this projection a transverse section of this portion of the urethra is curved or crescentic, with the convexity directed forwards. On either side of the crest there is a longitudinal groove, called the **prostatic sinus,** into which the majority of the prostatic ducts open. A few of these ducts, however, from the middle lobe open in the median line above the crest, or, if the crest commences at the lower end of the uvula vesicæ, upon its upper part. Immediately below the most prominent part of the crest there is the opening of a small blind recess, called the **utricle.** The other names by which it is known are *sinus pocularis, vesicula prostatica,* and *uterus masculinus.* Its direction is upwards and backwards behind the middle lobe of the prostate, and it is from ¼ to ½ inch in length. It is somewhat flask-shaped, being narrow at its urethral orifice, but expanded at its deep cæcal end. Upon the lateral margins of its orifice, or it may be just within them, there are the minute openings of the common ejaculatory ducts. The utricle represents the uterus and vagina in the female, being developed from the fusion of the posterior or caudal ends of the Müllerian ducts.

When the middle lobe of the prostate becomes hypertrophied, it blocks the urethral orifice of the bladder, as has been stated, by pressing the uvula vesicæ over it from behind, and so gives rise to difficulty in micturition, and obstructs catheterization. When both lateral lobes become uniformly hypertrophied, the prostatic portion of the urethra undergoes increase in length. When only one lateral lobe is involved in the hypertrophy it presses against the urethra, and, producing distortion of the canal, gives rise to difficulty in micturition, and often considerable obstruction in catheterization.

Structure.—The mucous membrane of the prostatic urethra is

surrounded externally by the inner circular muscular fibres of the prostate, and is covered internally by *transitional epithelium.*

The **membranous portion of the urethra** succeeds to the prostatic portion, and extends from the apex of the prostate gland to the commencement of the spongy portion. It is contained, for the most part, between the two layers of the triangular ligament, but it also extends for a short distance ($\frac{1}{4}$ inch) beyond the antero-inferior layer of that structure. It is the shortest and narrowest part of the canal, with the exception of the meatus urinarius. Its length is $\frac{3}{4}$ inch along the anterior wall, and $\frac{1}{2}$ inch along the posterior, the difference being due to the fact that the membranous urethra passes into the spongy part in a slanting manner at a point $\frac{1}{4}$ inch in front of the posterior extremity of the bulb. The back part of the bulb projects backwards for $\frac{1}{4}$ inch over the posterior wall of the membranous urethra, and is here lying in front of the antero-inferior layer of the triangular ligament. It is in this situation where a false passage is liable to be made in catheterization, partly because the walls are here very thin, and partly by reason of the backward extension of the posterior extremity of the bulb. The diameter of the membranous urethra is $\frac{1}{5}$ inch. It lies about 1 inch behind and below the subpubic ligament, and its direction is downwards and slightly forwards. It describes a gentle curve, the concavity of which looks forwards and upwards towards the lower part of the symphysis pubis. As the membranous urethra passes through the postero-superior layer of the triangular ligament, which is formed by the parietal pelvic fascia, the fascia is prolonged upwards to form part of the capsule of the prostate gland. Moreover, as it pierces the antero-inferior layer of the triangular ligament about 1 inch below the symphysis pubis, it carries with it a prolongation from the margins of the urethral opening, which forms a fascial investment for the bulb. Between the two layers of the triangular ligament the membranous urethra is surrounded by the fibres of the compressor urethræ muscle, and Cowper's glands lie behind it, one on either side of the middle line.

Structure.—External to the mucous membrane there is a layer of erectile tissue, and outside this there is a layer of circularly-disposed plain muscular fibres, which are continuous above with the circular muscular fibres of the prostate around the prostatic urethra. External to this, again, there are the sphincter fibres of the compressor urethræ. The mucous membrane is covered by *columnar epithelium.* The membranous portion of the urethra in transverse section presents the appearance of a circular opening, the lumen of which is branched, this being due to the longitudinal folds into which the mucous membrane is thrown.

The **spongy portion of the urethra** succeeds to the membranous portion. It is contained within the corpus spongiosum of the penis, and extends from a point $\frac{1}{4}$ inch in front of the posterior extremity of the bulb and of the antero-inferior layer of the triangular ligament to the meatus urinarius on the extremity of

the glans penis. It is about 6 inches in length, and its calibre is unequal throughout. It presents two dilatations, one situated in the **bulb** (which represents about the first 1½ inches of the corpus spongiosum), and the other in the glans penis, the latter being

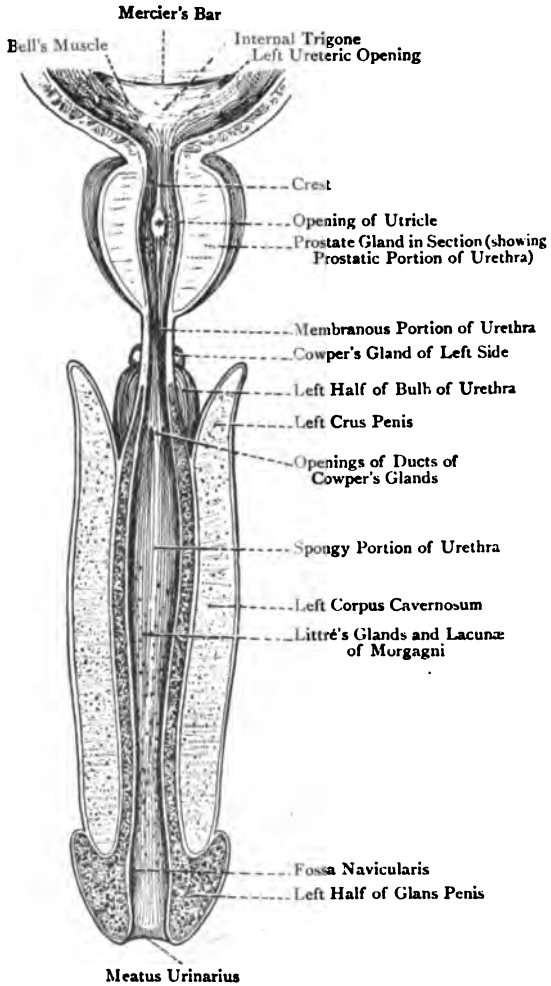


FIG. 356.—THE INTERIOR OF THE MALE URETHRA.

called the **fossa navicularis.** The bulbous enlargement is about 1¼ inches in length, whilst the fossa navicularis is about ½ inch long. The diameter of that part of the spongy urethra which intervenes between the bulbous enlargement and the fossa navi-

cularis is about ¼ inch. At the meatus urinarius the calibre of the canal is diminished, this being the narrowest part of the entire canal. The spongy portion at its commencement is directed forwards for a short distance, and then bends downwards. It thus describes a curve, which is situated about 2 inches from its commencement, the concavity being directed downwards. This curve is fixed, and corresponds with the **angle** of the penis, the situation of which is immediately in front of the penile attachment of the suspensory ligament, where drooping of the organ takes place. Another curve, but of a temporary nature, can be produced by raising the penis towards the abdomen, as in catheterization. The walls of the spongy part of the urethra are in contact, except during the passage of fluid. A transverse section of it, except in the glans, presents a transverse slit with anterior and posterior lips. In the glans, however, the slit is vertical with its lips laterally disposed. At the upper end of the fossa navicularis—that is, the end most remote from the meatus urinarius—the vertical slit is modified by the addition of a short transverse slit, and so presents the shape of an inverted T, as follows, ⊥.

Structure.—The mucous membrane of the spongy portion is provided with elastic tissue, and is very vascular. It is covered by *columnar epithelium*, except in the glans, where it is of the *stratified squamous* variety. Outside the mucous membrane is the submucous coat, which contains two layers of plain muscular tissue —inner longitudinal and outer circular. External to the submucous coat there is a plexus of veins, which forms part of the corpus spongiosum. The mucous membrane contains both simple and compound mucous glands, called the **glands of Littré**, the openings of the ducts of which are studded over the surface. In addition to these there are other openings, which lead into small blind recesses, called the **lacunæ of Morgagni,** these openings being directed forwards. One lacuna, of large size, called the *lacuna magna*, or *sinus of Guérin*, is situated on the roof of the fossa navicularis, about 1 inch from the meatus urinarius. The mucous membrane which surrounds this lacuna is known as the *valvule of Guérin*. Besides the foregoing openings, the ducts of Cowper's glands open upon the floor of the bulbous portion of the urethra about 1 inch in front of the antero-inferior layer of the triangular ligament.

There is sometimes a congenital deficiency in the floor of the spongy urethra, constituting the condition known as hypospadias. In other cases the deficiency may be on the roof, and it is then known as epispadias.

Lymphatics of the Urethra.—The lymphatics of the prostatic portion pass to the *internal iliac glands*, and those of the spongy portion pass to the *inguinal glands*. The lymphatics of the membranous portion pass partly with those of the prostatic portion to the internal iliac glands, and partly with those of the spongy portion to the inguinal glands.

Pelvic Colon.—The pelvic colon succeeds to the iliac colon. It commences at the inner border of the left psoas magnus, just anterior to the left sacro-iliac articulation, and terminates in front of the third sacral vertebra, where it becomes continuous with the rectum. It measures on an average about 15 inches in length, and usually lies in the pelvic cavity over the upper part of the posterior wall, where it rests below upon the bladder and rectum, and may descend on either side of these viscera. It is surrounded by peritoneum, which forms behind it an expanded wavy mesentery, called the **pelvic meso-colon,** which contains between its two layers the lower two sigmoid and superior hemorrhoidal arteries, with the corresponding veins. The root of this mesentery is composed of two limbs, which become continuous at an acute angle. One limb takes an upward course along the inner border of the psoas magnus, and the other passes downwards over the sacral promontory to be attached to the anterior surfaces of the first three sacral vertebræ. At its extremities, which are near each other, the mesentery is short, and the extremities of the pelvic colon are necessarily fixed. The intervening portion, however, is long, and so allows of considerable mobility on the part of the greater portion of the attached gut. A very common course for the pelvic colon to take is to pass to the right wall of the pelvis, where it bends and crosses to the left wall, and then bending again it passes to the right as far as the middle line. In such cases, therefore, it describes the letter **S**. A portion of it is sometimes met with in the abdominal cavity.

Structure.—The chief difference in the structure of the pelvic colon, as compared with the other divisions of the colon, affects the arrangement of the longitudinal muscular fibres. Though arranged at first in three tæniæ, these gradually become disposed as two broad tæniæ, anterior and posterior. When this has taken place, the longitudinal fibres almost surround the gut, except along the sides, in which situations the usual sacculations are formed. Appendices epiploicæ are met with over the pelvic colon.

Blood-supply.—The pelvic colon receives its **arteries** from the lower two sigmoid arteries, which are branches of the inferior mesenteric. The **veins** pass to the inferior mesenteric vein, and ultimately into the vena portæ.

The **lymphatics** pass to the *left lumbar lymphatic trunk.*

The **nerves** are derived from the inferior mesenteric sympathetic plexus.

Rectum.—The rectum succeeds to the pelvic colon, and extends from the front of the third sacral vertebra to a point 1½ inches in front of and below the tip of the coccyx, where it pierces the pelvic diaphragm, and terminates in the anal canal. Its direction is at first downwards and slightly backwards, then vertically downwards, and finally downwards and forwards. It is fully 5 inches in length, and its diameter, for the most part, is about

1½ inches in the empty state, but it becomes enlarged above the anal canal, this dilated part being called the **ampulla.** When empty, its anterior and posterior walls are in contact, and in transverse section it appears as a transverse slit. The rectum is destitute of a mesentery. The peritoneum covers the upper third *laterally* and *anteriorly*, but not posteriorly, the middle third being covered by peritoneum *only anteriorly*, whilst the lower third is free from serous covering. The point at which the peritoneum leaves the bowel is usually about 3 inches above the anus.

The rectum, so far from being straight in man, presents both antero-posterior and lateral curves. The **antero-posterior curves** are two in number, upper and lower. The *upper* curve extends from the third sacral vertebra to the posterior or rectal surface of the prostate gland, and its concavity is directed forwards. The *lower* curve, which is abrupt, corresponds with the rectal surface of the prostate, its concavity looking backwards, and containing the ano-coccygeal body. The **lateral curves** are of importance, because they tend to obstruct the passage of instruments by giving rise to the valves of Houston. These curves are usually three in number—upper, middle, and lower. The *upper* and *lower* curves have their convexities directed towards the right, whilst the *middle* curve has its convexity directed towards the left. In the concavities of these curves the rectal wall becomes inflected, and so gives rise to more or less prominent shelves of mucous membrane, which are known as the rectal valves of Houston. The lateral inflections and resultant valves are associated with the erect posture of man, which posture throws considerable pressure upon the anal aperture and its sphincter muscles. They are best marked in the distended rectum, and the lateral curves are brought about in the following manner: The longitudinal muscular fibres of the rectum are rather shorter than the gut to which they are applied. Moreover, they are principally disposed in two stout broad sheets, one on the anterior and the other on the posterior wall, there being very few longitudinal fibres along the lateral walls. The shortness of these longitudinal fibres, therefore, throws the rectum into lateral curves on account of the sparseness of the longitudinal fibres at the sides. These lateral curves may be taken as representing the sacculations of the other parts of the colon.

Relations—*Anterior.*—The recto-vesical pouch of peritoneum for a short distance; the base of the bladder, vesiculæ seminales, and vasa deferentia, with the intervention of the recto-vesical lamina of the visceral pelvic fascia; and the posterior or rectal surface of the prostate gland, with the intervention of the recto-prostatic lamina of the visceral pelvic fascia. In the female the anterior relations are (1) the recto-uterine pouch of peritoneum, or pouch of Douglas, with a few coils of small intestine, in front of which are the posterior surface of the body of the uterus and the upper part of the posterior wall of the vagina; and (2) the greater portion of the posterior wall of the vagina. *Posterior.*—The lower three

sacral vertebræ, coccyx, levatores ani, and ano-coccygeal body. Behind the rectum there is a large amount of areolar tissue. *Lateral.*—The pelvic sympathetic plexuses, levatores ani, and coccygei muscles, the lateral divisions of the superior hemorrhoidal artery, and the corresponding veins.

Anal Canal (Symington).—This is the terminal portion of the large intestine. It extends from the lower end of the rectum, where that has pierced the pelvic diaphragm at a point corresponding to the apex of the prostate gland, to the anus, and it is the part which is surrounded by the sphincter muscles. It is about 1½ inches in length, and its lateral walls are in contact, so that in transverse section it appears as an antero-posterior slit, in which respect it differs from the rectum proper. Its direction is downwards and backwards, and its antero-posterior measurement is from ½ to ¾ inch.

Relations—*Anterior.*—The bulb of the corpus spongiosum, the base of the triangular ligament, and the membranous part of the urethra. In the female the perineal body is anterior to it, and separates it from the lower end of the vagina. *Posterior.*—The ano-coccygeal body. *Lateral.*—The fat of the ischio-rectal fossæ. The anal canal is closely guarded by muscles in the following manner, and to the following extent: the sphincter ani externus surrounds its termination in the anal aperture, the levatores ani grasp it at its commencement, and the intervening part is surrounded by the sphincter ani internus. For the structure and development of the rectum and anal canal, see p. 818 *et seq.*

Parts felt per Rectum in Catheterization.—A catheter having been passed into the bladder, the following parts, in order from before backwards, may be felt through the anterior wall of the bowel on the introduction of the index finger: (1) the membranous portion of the urethra; (2) the posterior or rectal surface of the prostate gland; and (3) the apical part of the external trigone of the bladder, destitute of peritoneum, with a vas deferens on either side, and very near each other—indeed, almost touching. During this examination the finger may come in contact with the lower left, and perhaps the right, valve of Houston.

Middle Sacral Artery.—This vessel arises from the posterior aspect of the abdominal aorta just above the bifurcation. Its course is downwards in the middle line, behind the left common iliac vein and the hypogastric sympathetic plexus, and it rests in succession upon the following parts: the lower half of the body of the fourth lumbar vertebra and the disc between it and the fifth, the body of the fifth lumbar and the disc between it and the first sacral vertebra, and the pelvic surfaces of the sacrum and coccyx. In the pelvis it lies within the root of the pelvic meso-colon, being covered by a portion of the pelvic colon, as low as the third sacral vertebra, and beyond that it is placed behind the rectum. On reaching the tip of the coccyx it terminates in the coccygeal body. The branches of the artery are as follows: *anterior* or *rectal* to the posterior wall of the rectum, where they anastomose with the superior and

middle hemorrhoidal arteries; *lateral* to the front of the sacrum and coccyx, which anastomose with the lateral sacral arteries; and *terminal* to the coccygeal gland. The vessel occasionally furnishes a fifth pair of lumbar arteries, which wind round the sides of the body of the fifth lumbar vertebra.

The middle sacral artery represents the caudal aorta of animals, and its lateral branches are serially homologous with the lumbar branches of the abdominal aorta.

The **middle sacral vein** is at first arranged as two venæ comites, but these subsequently unite to form a single vessel, which usually terminates in the left common iliac vein.

Coccygeal Gland (Body) of Luschka.—This so-called gland is situated in front of the tip of the coccyx. It is about the size of a small pea, and is composed of a few nodules which are held together and invested by connective tissue. It receives the terminal twigs of the middle sacral artery. In structure it consists of groups of polyhedral cells, united by connective tissue, and permeated by blood-capillaries and sympathetic nerve-filaments. It is similar to the *carotid body*, which is situated behind the common carotid artery of each side close to its bifurcation.

Sacral Glands.—This group comprises a few lymphatic glands which lie in front of the sacrum along the middle line, behind the rectum. They receive their afferent vessels from the rectum and upper part of the anal canal, and from the posterior wall of the pelvis, and their efferent vessels pass to the *median lumbar glands*.

Gangliated Cord of the Sympathetic.—This is situated close to the inner side of the anterior sacral foramina. The two cords, right and left, converge as they descend, and in front of the coccyx they are connected by a loop which sometimes presents a single median ganglion, called the *ganglion impar* or *coccygeal ganglion*. The number of ganglia on each cord is usually four.

Branches.—(1) **Grey rami communicantes**, which spring from the ganglia and pass to the anterior primary divisions of the sacral and coccygeal nerves. These rami are very short. (2) **Visceral branches,** which pass from the upper one or two ganglia to the pelvic plexus. (3) **Parietal branches,** which are distributed over the front of the sacrum, and which communicate with those of the opposite side, so as to form a plexus upon the middle sacral artery. From the terminal loop and ganglion impar (when present) branches proceed to the front of the coccyx and coccygeal body. The ganglia of the sacral chain do not receive any white rami communicantes from the sacral nerves, these, under the name of the *pelvic splanchnics*, going chiefly to the pelvic plexus.

Levator Ani—*Origin.*—(1) The posterior surface of the body of the os pubis in its lower part, below the attachment of the pubo-prostatic or anterior true ligaments of the bladder, and above the attachment of the parietal pelvic fascia; (2) the internal surface of the parietal pelvic fascia along the **white line**; and (3) the pelvic

surface of the spine of the ischium in its lower part, below the coccygeus.

Insertion.—(1) The side of the lower part of the coccyx; (2) the post-anal or ano-coccygeal raphé, where it meets its fellow of the opposite side; (3) the wall of the anal canal, where the fibres blend with the longitudinal fibres of the gut, and ultimately pass with them between the external and internal sphincter muscles to be attached to the anal integument; and (4) the pre-anal raphé, and the central tendinous point of the perineum, where the muscle again meets its fellow of the opposite side.

The levator ani is a broad, flat, and thin fleshy muscle, the direction of which is downwards, inwards, and backwards, and with its fellow of the opposite side it forms an incomplete muscular floor to the pelvic cavity. It is covered on its pelvic aspect by the visceral portion of the pelvic fascia, and on its perineal aspect by the anal fascia, and in this manner a separation is formed between one half of the pelvic cavity and the ischio-rectal fossa of the same side.

The anterior border is free close to the body of the os pubis, but, after it passes downwards and backwards upon the side of the prostate gland in the male, or vagina in the female, it meets its fellow of the opposite side, between the prostate gland and the commencement of the membranous part of the urethra in the male on the one hand, and the rectum on the other, or between the vagina in the female and the rectum, the meeting taking place in the pre-anal raphé. Between the anterior borders of the two muscles the membranous part of the urethra in the male, and the vagina in the female, emerge from the pelvic cavity. The anterior or pubo-prostatic fibres are sometimes spoken of as the **levator** or **compressor prostatæ.** The posterior border adjoins the coccygeus muscle.

Nerve-supply.—(1) The anterior primary division of the fourth sacral nerve, and (2) the perineal branch of the pudic nerve (deep division).

Action.—(1) To elevate and support the floor of the pelvis, thus diminishing the vertical measurement of the abdominal cavity; (2) to compress the anal canal, and so assist in expelling its contents; (3) to elevate the anus; (4) to elevate and compress the prostate gland in the male, and the vagina in the female; and (5) to flex the coccyx.

Coccygeus (ischio-coccygeus)—*Origin.*—(1) The pelvic surface of the spine of the ischium, above the origin of the posterior fibres of the levator ani, and (2) slightly from the inner surface of the parietal pelvic fascia above the ischial spine.

Insertion.—The side of the upper two coccygeal and lower two sacral vertebræ.

Nerve-supply.—The anterior primary divisions of the fourth and fifth sacral nerves.

Action.—To flex the coccyx.

The coccygeus is a thin, flat, triangular muscle, the fleshy fibres having a large admixture of tendinous fibres. The internal or pelvic surface is related to the visceral pelvic fascia, sacro-coccygeal plexus and rectum, and the external surface to the small sacro-sciatic ligament. The superior border is adjacent to the pyriformis, with the intervention of the structures which leave the pelvis below that muscle. The inferior border adjoins the posterior border of the levator ani.

The coccygeus muscle is to be regarded as a detached portion of the levator ani.

The levatores ani and coccygei muscles form the *pelvic diaphragm*, which presents a superior concave, and an inferior convex, surface. The greater part of this diaphragm is formed by the levatores ani, and this part of it gives passage in the middle line to the rectum.

Pyriformis—*Origin.*—(1) By three fleshy slips from the anterior surfaces of the second, third, and fourth sacral vertebræ, which are interposed between, and lie external to, the adjacent anterior sacral foramina; (2) the deep surface of the great sacro-sciatic ligament; and (3) the posterior border of the ilium immediately below the posterior inferior spine.

Insertion.—The upper border of the great trochanter of the femur near its centre.

Nerve-supply.—Two branches from the sacral plexus, more particularly from the dorsal divisions of the first and second sacral nerves.

Action.—External rotator of the thigh.

The intrapelvic portion of the muscle is covered by a prolongation of the parietal pelvic fascia, called the fascia of the pyriformis, and it supports the nerves of the sacral plexus, branches of the anterior division of the internal iliac artery, and pelvic colon. For the extrapelvic portion, see p. 404.

Obturator Internus—*Origin.*—(1) The internal surface of the obturator membrane; (2) the posterior surface of the body and descending ramus of the os pubis, and ramus of the ischium; (3) the inclined plane of the ischium, extending as far back as the great sacro-sciatic foramen, and nearly as high as the iliac portion of the ilio-pectineal line; and (4) the parietal pelvic fascia covering the muscle.

Insertion.—The inner surface of the great trochanter above and in front of the digital fossa.

Nerve-supply.—The nerve to the obturator internus, from the sacral plexus.

Action.—External rotator of the thigh.

Relations of Intrapelvic Part—*Internal.*—As low as the *white line* the internal surface of the muscle is covered by the parietal pelvic fascia and peritoneum with the subperitoneal areolar tissue, and it is directed towards the pelvic cavity. The obturator vessels and nerve here lie between the subperitoneal areolar tissue and the parietal pelvic fascia. Below the level of the white line the internal

surface is still covered by the parietal pelvic fascia, which constructs Alcock's canal. This portion of the muscle lies upon the outer wall of the ischio-rectal fossa. *External.*—The internal surface of the obturator membrane, and the surrounding bone. For the extrapelvic part of the muscle, see p. 405.

STRUCTURE OF THE VISCERA OF THE MALE PELVIS.

The Bladder.

The wall of the bladder is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, and is very limited in its extent, being confined to the superior surface. It forms the false ligaments of the viscus.

The **muscular coat** consists of plain muscular tissue, which is arranged in three layers—external longitudinal, middle circular, and internal longitudinal.

The *external longitudinal fibres* are most apparent on the superior and inferior surfaces. Laterally they are scarce, and are disposed in an interlacing manner. They have an independent bony attachment to the posterior aspects of the bodies of the pubic bones near the lower part of the symphysis, where they constitute the so-called *pubo-vesical muscles.* They then pass within the pubo-prostatic ligaments to the neck of the bladder, where they are connected with the base of the prostate gland. Having covered the inferior surface as far forwards as the apex, some of them are there prolonged along the urachus for a short distance, whilst others turn to the superior surface over which they pass to the base. Having descended upon the base, they enter the prostate gland, where they blend with its muscular tissue. The longitudinal stratum has been called the **detrusor urinæ muscle** from its supposed function in expelling the urine from the bladder.

The *middle circular fibres* are somewhat indistinct, and more or less reticular over the greater part of the viscus. In the region where the fundus and inferior surface meet they become more distinct, and around the neck of the bladder, where the urethral opening is situated, they form a tolerably well-marked annular bundle, known as the **sphincter vesicæ,** beyond which they are continuous with the muscular tissue of the prostate gland.

The *internal longitudinal fibres* are somewhat indefinite, and are chiefly recognisable on the inferior surface.

When portions of the mucous membrane project between the scattered muscular bundles, the bladder is said to be *sacculated.* When, on the other hand, the muscular bundles become hypertrophied from any cause, such as enlarged prostate or stricture, they give rise to inward projections of the mucous coat, which are

arranged in a coarsely reticular manner, a condition known as the *fasciculated bladder*.

The **submucous coat** is situated between the muscular and mucous coats, which it connects in a loose manner for the most part, and it is composed of areolar tissue with an admixture of elastic tissue. It serves as a bed in which the arteries and nerves subdivide before entering the mucous coat.

The **mucous coat** is soft in consistence, and of a pinkish colour in health. It is continuous with the mucous membrane of the ureters and urethra, and over the greater part of the empty bladder is thrown into folds, which, however, disappear as the viscus becomes distended. This rugose condition is explained by the loose connection which exists between the mucous and muscular coats through means of the submucous coat. Over the internal trigone, however, to be presently described, the mucous membrane is quite smooth, and also very sensitive. The mucous coat is covered by stratified transitional epithelium, similar to that of the ureters. In the most superficial layer the cells are cubical, and they present depressions on their deep surfaces, which receive the round ends of the pyriform cells of the layer beneath. In the second layer the cells are pyriform, the round ends being capped by the cubical cells of the first layer, and the narrow ends being deeply placed amongst the deeper cells. In the third and fourth layers the cells are round or oval.

Orifices of the Bladder.—These are three in number, namely, urethral, and two ureteric. The **urethral orifice** is the opening by which the urine leaves the bladder, and it is situated at the posterior extremity of the inferior surface, where it meets the base. This is the most dependent part of the viscus, and corresponds with the neck, which is surrounded by the base of the prostate gland. Immediately above the urethral orifice the mucous membrane presents a short median vertical ridge, which projects forwards over the orifice. This ridge is called the *uvula vesicæ*. It is produced by the middle lobe of the prostate gland, and is much more conspicuous when that lobe is enlarged. The **ureteric openings** assume the form of small slit-like, somewhat elliptical, apertures, which are about 1¼ inches apart, and an equal distance from the urethral orifice, their direction being obliquely downwards and inwards. The ureters, before so terminating, have pierced the vesical wall obliquely, lying in it for about ¾ inch, and in this manner reflux of urine is prevented.

Internal Trigone of the Bladder.—This is situated at the lower part of the basal surface, and the mucous membrane over it is so closely connected to the muscular coat that it is always smooth, and so presents a marked contrast to the rugose condition of the mucous membrane over the rest of the empty bladder. The trigone assumes the form of an equilateral triangle, the angles of which correspond with the urethral and ureteric openings, whilst the sides are constructed by ridges connecting these openings. The inter-ureteric ridge, called *Mercier's bar*, is produced by a

bundle of muscular fibres, and is slightly convex, with the convexity directed downwards towards the urethral orifice. The urethro-ureteric ridge on either side is also produced by a bundle of muscular fibres, these bundles being known as the *muscles of Bell*. The uvula vesicæ is situated at the lower part of the trigone in the middle line, above the urethral orifice.

Lumen of the Empty Bladder.—This is very small, and is composed of two limbs, anterior and posterior. The *anterior limb*, which is long, lies almost horizontally in front of the urethral orifice, and is formed by the juxtaposition of the superior and inferior walls. The *posterior limb*, which is short, is directed upwards and backwards, and is formed by the juxtaposition of the back part of the superior wall and the base. The anterior and posterior limbs join each other at the urethral orifice, and are there continued onwards into the lumen of the prostatic urethra. A triradiate appearance is thus imparted to the lumen of the empty bladder and of the prostatic urethra, the three rays diverging from a central point, namely, the urethral orifice, one ray being urethral, and two vesical, of which latter one is the anterior limb of the vesical lumen, and the other the posterior limb.

The Infantile Bladder.—The bladder in early life is pyriform. The narrow end is directed downwards, and is on a level with the upper border of the symphysis pubis, from which point it gradually descends as age advances. The broad end is directed upwards, and lies in the hypogastric region of the abdomen. The base is absent at this period, and the anterior surface of the viscus, devoid of peritoneum, is in contact with the posterior surface of the anterior wall of the abdomen, which is likewise destitute of peritoneum. There being no base, the bottom of the recto-vesical pouch of peritoneum lies close to the base of the prostate gland.

Ligaments of the Bladder.—These are arranged as false and true ligaments. The **false ligaments** are formed by the peritoneum, and are five in number, as follows: *two posterior*, which represent the laterally-disposed lips of the mouth of the recto-vesical pouch; *two lateral*, right and left, which represent the reflection of the peritoneum from each lateral border of the bladder to the corresponding lateral wall of the pelvis; and *superior*, which is the reflection of the peritoneum from the apex of the bladder to the posterior surface of the anterior abdominal wall along the urachus. The **true ligaments** are also five in number, as follows: *two lateral*, right and left, which are formed by the vesical layers of the visceral portion of the pelvic fascia on the sides of the bladder; *two anterior* or *pubo-prostatic*, which are the reflections of the visceral pelvic fascia from the back of the bodies of the pubic bones near the lower part of the symphysis to the neck of the bladder, and which pass in their course over the anterior surface of the prostate gland; and *superior*, which is the urachus. Each anterior true ligament contains some of the external or longitudinal muscular fibres of the bladder.

Blood-supply—Arteries.—These are as follows: (1) superior vesical, from the pervious portion of the obliterated hypogastric; (2) inferior vesical, from the anterior division of the internal iliac; (3) vesical, from the intrapelvic portion of the obturator; (4) vesical, from the intrapelvic portion of the sciatic; and (5) branches from the uterine and vaginal arteries in the female.

Veins.—These are very copious, and are arranged in two plexuses—superior vesical and prostatico-vesical. The **vesical plexus** is situated over the fundus and sides of the bladder, and its blood is conveyed into the prostatico-vesical plexus. The **prostatico-vesical plexus** is composed of two parts, continuous with each other, namely, vesical and prostatic. The *vesical portion* surrounds the neck of the bladder, and its blood is conveyed by one or more vesical veins into the internal iliac vein.

Lymphatics.—These pass to the *external* and *internal iliac glands*.

Nerves.—Each half of the bladder receives sympathetic and spinal fibres from the following sources: (1) the pelvic plexus of the sympathetic, which contains spinal fibres from the third and fourth sacral nerves (sometimes also from the second), these being known as the *pelvic splanchnics;* and (2) special twigs from the pelvic splanchnics, which can be traced independently to the bladder. It is to be noted that the bladder also receives spinal fibres from the upper two or three lumbar nerves through the intervention of (*a*) the ganglia of the lumbar sympathetic cord, (*b*) the aortic plexus, (*c*) the hypogastric plexus, and (*d*) the pelvic plexus.

Structure of the Penis.

Corpora Cavernosa.—Each corpus cavernosum has a strong capsule, called the **tunica albuginea.** This tunic is composed of fibrous, plain muscular, and elastic tissues. It is disposed in two laminæ—external and internal. The fibres of the external lamina are arranged longitudinally, and are common to both corpora cavernosa. The fibres of the internal lamina run circularly round each corpus cavernosum, and in the middle line those of each side meet and are prolonged inwards as a septum, which is imperfect except near the root of the penis, being traversed by vertical clefts. This partition is called the **septum pectiniforme.** From the inner surface of the tunica albuginea strong trabeculæ are given off, which penetrate into the interior of the corpus cavernosum. These trabeculæ, which are fibro-muscular and elastic in character, are arranged in a reticular manner, and enclose the cavernous spaces of the erectile tissue. The artery of the corpus cavernosum lies in the centre, and, in addition to this chief vessel, several other arteries, derived from the dorsal artery of the penis, enter it from the surface. The branches of these arteries run in the trabeculæ, and terminate in capillaries, which pour their blood directly into the cavernous or intertrabecular spaces. Some of the small arteries in the trabeculæ are thrown into spiral loops, which project into the intertra-

becular spaces. Such vessels are called the ***helicine*** (spiral) ***arteries*** (Müller). From the intertrabecular spaces the radicle veins proceed, and by them the blood is returned from the organ.

Corpus Spongiosum.—This differs from the corpora cavernosa in being destitute of any bony attachments. Its length is about 6 inches, and it is expanded at either end. It is divided into a bulb, body, and glans. The glans has been already described (see p. 609). The **bulb** represents about the first $1\frac{1}{2}$ inches of the corpus spongiosum, and at its widest part it measures $\frac{3}{4}$ inch. It

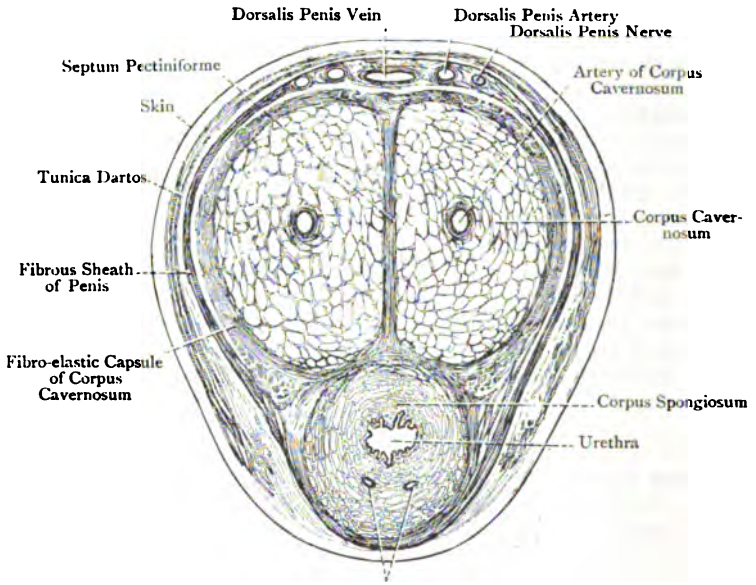


FIG. 357.—TRANSVERSE SECTION OF THE PENIS OF A CHILD AS SEEN UNDER A LOW POWER.

is surrounded by the bulbo-cavernosi muscles, and its enlarged posterior extremity rests upon the front of the antero-inferior layer of the triangular ligament of the urethra, where it is about 1 inch in front of the anus. The **body** is cylindrical. It has a capsule or tunica albuginea, but this is very thin. Within the capsule there is the erectile tissue, which resembles that of the corpora cavernosa, though not so well developed, and in the centre is the spongy portion of the urethra. The corpus spongiosum is traversed by the arteries of the corpus spongiosum, right and left, which are branches of the internal pudic arteries. They are situated underneath the urethral canal, one on either side of the middle line.

The venous blood of the corpora cavernosa and corpus spongiosum

is returned by the dorsal vein of the penis, and by the internal pudic venæ comites.

For the structure of the different parts of the urethra, see p. 800 *et seq.*

Development of the Bladder and Urethra—The Allantois.—The allantois is a hypoblastic diverticulum from the ventral wall of the hind-gut, which, with an investment of mesoblast, extends into the space between the true and false amnion. There are, therefore, two constituent parts in the allantois, namely, the hypoblastic diverticulum and its mesoblastic investment. This latter receives the embryonic allantoic or umbilical arteries, and, being very vascular, it carries bloodvessels to the villi of the chorion. The allantois thus establishes a communication between the hind-gut, which is intra-embryonic, and the chorion, which is extra-embryonic, and functionally it is associated with the nutritive and respiratory processes of embryonic life. The extra-embryonic and intra-embryonic parts are in continuity with each other through the umbilical opening. The former is of interest on account of its mesoblastic constituent, which, as has been stated, carries blood to the chorionic villi, and gives rise to the fœtal element of the placenta. The intra-embryonic part of the allantois is at first directly continuous with the upper part of the bladder, but in the course of the second month its lumen usually disappears, and then this portion is transformed into a fibrous cord, which is called the **urachus.** It is, however, to be noted that the lumen of the intra-embryonic part of the allantois may remain persistent for some time, thus giving rise to the condition which is known, after birth, as an umbilical urinary fistula.

The **bladder** is developed from the anterior or cephalic part of the ventral or uro-genital compartment of the cloaca, to which part the ureters are shifted when they cease to be connected with the Wolffian ducts. The *upper* portion of the **prostatic urethra,** as low as the sinus pocularis or uterus masculinus, is also developed from the anterior or cephalic part of the uro-genital compartment of the cloaca. and in the female the whole of the urethra is formed from it. The posterior or caudal part of this compartment, beyond the point of entrance of the Wolffian ducts, forms the uro-genital sinus. In the male it gives rise to the *lower* portion of the **prostatic,** and the *whole* of the **membranous, urethra,** whilst in the female it forms the portion of the uro-genital fissure close to the openings of the vagina and urethra.

It is to be noted that the upper portion of the prostatic urethra, as low as the sinus pocularis, represents the urethra of the female, whilst the uterus masculinus represents both the uterus and the vagina in the female, being developed from the fusion of the posterior or caudal ends of the Müllerian ducts. The cavity of the bladder is at first in direct continuity above with the lumen of the intra-embryonic part of the allantois.

Another view of the development of the bladder is that it is formed by a dilatation of the allantois at its proximal or cloacal end.

Development of the Spongy Portion of the Urethra.—The **cloaca,** which is the common opening of the hind-gut and uro-genital ducts, is bounded behind and below by a membrane, called the **cloacal membrane.** This membrane in very early embryonic life shuts off the cavity of the hind-gut from the exterior. It is composed of two layers, internal or hypoblastic belonging to the hind-gut, and external or epiblastic which is an invagination of the epiblast. The cloacal membrane forms the floor of a fossa, called the **cloacal fossa.** In the course of the second month the cloaca itself becomes partitioned off into two compartments by a septum formed of two lateral tranverse portions, which fuse in the middle line. The dorsal division is called the *rectal compartment,* and the ventral is termed the *uro-genital compartment.* Shortly afterwards a transverse fold appears, which crosses the cloacal fossa in such a position as to coincide with the posterior end of the internal partition. This transverse fold is called the **perineal fold.** In the female it gives rise to the perineum proper, and in the male it forms the tegmental parts of that

portion of the perineum which lies between the scrotum and the anus. The part of the cloacal fossa behind the perineal fold forms the **anal depression** or **proctodeum,** and the portion of the cloacal membrane which forms it is called the **anal membrane.** When the anal membrane disappears (about the third month) the anus becomes formed, and the rectal compartment of the cloaca now opens into the back part of the cloacal fossa. The uro-genital sinus, which is the posterior portion of the uro-genital compartment of the cloaca, opens into the cloacal fossa in front of the perineal fold by means of a narrow vertical cleft, called the **uro-genital cleft.** Shortly before the completion of the division of the cloaca into its two compartments (namely, about the fifth or sixth week), a prominence makes its appearance at the anterior or cephalic part of the cloacal membrane. This prominence receives the name of the **genital** or **sexual eminence,** and its importance consists in the fact that the penis and clitoris are developed from it. Leading backwards from the genital eminence there is a furrow, which ends at the uro-genital cleft. The genital eminence is surrounded at the front and sides by an epiblastic fold, called the **genital fold,** which, as it extends backwards, encloses between its two epiblastic layers the cloacal fossa and the cloacal membrane. The posterior surface of the genital eminence presents a groove, which is continuous with the uro-genital furrow. The lips of this groove, by their subsequent meeting and fusion, form a canal, which represents the part of the spongy urethra contained in the glans penis. Posterior to this the lips of the uro-genital furrow come together and unite as far back as the uro-genital cleft, and thus convert the front part of the cloacal fossa into a canal, which represents the spongy part of the urethra *behind the glans.* The spongy part is thus to be regarded as a forward extension of the uro-genital sinus, which opens at the uro-genital cleft. When the lips of the uro-genital furrow fail to meet and unite at any part, the condition known as hypospadias is produced, in which the spongy urethra opens externally on the under surface of the body of the penis. It is to be noted that, whilst the *prostatic* and *membranous portions* of the urethra are developed from the ventral or uro-genital compartment of the hypoblastic cloaca, the *spongy portion* is developed from the anterior part of the epiblastic cloacal fossa, the posterior part of that fossa giving rise to the anus and anal canal.

Structure of the Vesiculæ Seminales.

Each vesicula seminalis consists of a tube which is thrown into a number of coils, these being held together by fibrous tissue. When these coils are undone, and the tube straightened out, it measures from 5 to 6 inches in length. Its upper end is closed, and along its course several diverticula are met with. Each seminal vesicle in its natural sacculated condition is surrounded by a sheath, which is derived from the recto-vesical lamina of the visceral portion of the pelvic fascia. Within this sheath the tube has a fibrous wall composed of delicate fibrous tissue, and within this there is a muscular coat, which is formed of plain muscular tissue arranged in two layers—outer longitudinal and inner circular. Within the muscular coat is the mucous coat, which presents a number of reticular ridges with intervening alveoli. It thus bears a resemblance to honeycomb, in which respect it corresponds with the mucous membrane of the ampulla of the vas deferens and of the gall-bladder, the last-named having coarser meshes. The epithelium which covers the mucous membrane is of the columnar non-ciliated variety.

Blood-supply—Arteries.—These are derived from the inferior

vesical, the middle hemorrhoidal, the descending branch of the deferential artery, and the intrapelvic portion of the sciatic.

The **veins** are fairly large and numerous, and are disposed in a plexiform manner. They communicate with the prostatico-vesical plexus.

Lymphatics.—These go to the *internal iliac glands.*

Nerves.—These are derived from the pelvic plexus.

Development.—Each vesicula seminalis is developed as a diverticulum from the posterior or caudal part of the Wolffian duct, from which the vas deferens originates.

Structure of the Common Ejaculatory Ducts.

The wall of each duct is composed of three layers, as follows : an outer **fibrous layer,** which is very delicate ; a middle **muscular layer,** composed of an *outer circular* and *inner longitudinal* stratum ; and an inner **mucous layer,** lined by columnar non-ciliated epithelium.

Development.—Each duct is developed from the posterior or caudal part of the Wolffian duct.

Structure of the Prostate Gland.

The prostate gland is encased in a strong capsule, which is formed principally by the visceral portion of the pelvic fascia, and partly by the parietal pelvic fascia, in the following manner : the anterior wall of the capsule is formed by the prostatic lamina, and the posterior wall by the recto-prostatic lamina, of the visceral portion of the pelvic fascia ; and on either side the capsule is joined by the corresponding half of the deep or postero-superior layer of the triangular ligament of the urethra (which is formed by the parietal pelvic fascia), after it has passed backwards over the anterior border of the corresponding levator ani muscle. The capsule has a material influence in fixing the prostate gland in its position. Within this capsule there is the prostatic plexus of veins, and within this plexus there is another special capsule, composed of fibrous tissue, which immediately surrounds the glandular substance. The prostatic venous plexus is thus enclosed between the two capsules. The substance of the gland is composed of two elements—muscular and glandular. The **muscular tissue,** which is of the plain variety, is arranged as (1) an external, partly longitudinal and partly transverse, layer, which lies beneath the special fibrous capsule, and (2) an internal circular layer, which surrounds the prostatic urethra, being continuous above with the fibres of the sphincter vesicæ, and below with those around the membranous portion of the urethra. Between these two layers the muscular fibres pervade the gland in a decussating manner, so as to construct a muscular reticulum, the meshes of which contain the

glandular tissue. The chief part of the gland in front of the urethra is composed of muscular tissue. The **glandular element** consists of branched tubular alveoli or acini, the walls of which are formed by a basement membrane, covered internally by columnar epithelium. The tubular alveoli lead into the excretory or prostatic ducts, the structure of which is similar to that of the gland-tubes. The ducts average twenty in number, ten on either side, and they open by independent orifices upon the posterior wall of the prostatic portion of the urethra, for the most part into the prostatic sinus on either side of the crest.

Blood-supply—Arteries.—These are derived from the inferior vesical, the middle hemorrhoidal, and the intrapelvic portion of the sciatic.

The **veins** form a copious **prostatic plexus,** which is most plentiful over the anterior and lateral surfaces. It receives in front the dorsal vein of the penis in two divisions, and discharges its blood into the plexus which surrounds the neck of the bladder, and thence by one or more vesical veins into the internal iliac vein. The prostatic plexus is liable to become much enlarged in old age.

Lymphatics.—These pass to the *internal iliac glands.*

Nerves.—These are derived from the pelvic sympathetic plexus.

Development.—The glandular part of the prostate is developed from the epithelium of the uro-genital sinus. The epithelial cells in the course of the third month send out ramifying branches, which are at first solid, but subsequently become tubular, and so form the glandular part.

Structure of the Rectum.

The wall of the **rectum** is composed of five coats—serous, fascial, muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, and, as has been stated, is imperfect.

The **fascial coat** represents a sheath which is derived from the visceral pelvic fascia. In front of the rectum it is composed of the recto-vesical and recto-prostatic laminæ, whilst posteriorly it is formed by the rectal lamina of that fascia. It is best marked over the lower third of the rectum, where the peritoneum is absent. Elsewhere it is comparatively thin, and over the peritoneal area it merges into the subperitoneal areolar tissue.

The **muscular coat** is well developed, and is composed of plain muscular tissue, arranged as an external longitudinal and internal circular layer. The *longitudinal layer* is present all round the gut, but attains its greatest development along the anterior and posterior walls, where it forms two broad stout laminæ. Along the sides it is somewhat sparse. The *circular fibres* form a continuous covering for the rectum, and inferiorly they become increased in amount around the anal canal, and so give rise to the *sphincter ani internus.*

The **submucous coat** is composed of areolar tissue, and connects

the muscular and mucous coats in a very loose manner, so that the latter is thrown into a number of temporary folds in the empty condition of the gut. The internal hemorrhoidal plexus of veins is embedded in this coat.

The **mucous coat** is characterized by great thickness and vascularity. In health, therefore, it has a reddish colour, and is capable of free movement upon the muscular coat. The mucous membrane is covered by columnar epithelium, and is provided with crypts of Lieberkühn and lymphoid nodules. It is thrown into a number of folds in the empty state, but the majority of these are temporary, and become effaced when the gut is distended. There are, however, at least three permanent folds, which constitute the rectal valves of Houston. The mucous membrane is also studded over with a number of minute tubular depressions, called *rectal pits*, which are surrounded at their deep ends by lymphoid tissue (Birmingham).

The **rectal valves of Houston** are usually three in number, two being situated on the *left side* of the rectum, and one on the *right side*, and they are disposed horizontally. They take the form of crescentic folds, which are produced by inflections of the rectal wall in the concavities of the lateral curves, and they are best marked when the gut is distended. Each valve is composed of the mucosa, submucosa, circular, and deepest longitudinal muscular fibres. The **right valve,** which is intermediate in position, and usually the largest, is situated fully 3 inches above the anus. The **left valves** are situated one about 1 inch above, and the other about 1 inch below, that of the right side. These valves are sustentacular in function, serving to support the rectal contents, and it is possible that they may give rise to obstruction in the passage of instruments.

Structure of the Anal Canal.

The wall of the anal canal is composed of three coats—muscular, submucous, and mucous. The **muscular coat** is composed of plain muscular tissue, arranged as an external longitudinal and internal circular layer. The *longitudinal fibres* are continuous with those of the rectum, and, blending with them, there are fibres of the levator ani. Inferiorly they pass between the internal and external sphincters, to be attached to the anal integument. Associated with the plain longitudinal fibres on the posterior wall of the anal canal there are two minute muscles (sometimes united into one), called the *recto-coccygei muscles*. These spring from the front of the coccyx, and descend upon the posterior wall, where they blend with the longitudinal fibres.

There is nothing specially noteworthy in the submucous coat.

The **mucous coat** presents the columns of Morgagni, and the anal valves of Morgagni. The **columns of Morgagni** are six or more in number, and take the form of permanent vertical folds,

which are confined to the upper two-thirds of the anal canal, where they are separated from each other by longitudinal grooves. They are composed of inflections of the mucous membrane, which contain plain muscular tissue belonging to the muscularis mucosæ, and two small bloodvessels. They stop short about ½ inch above the anus. The **anal valves of Morgagni** are situated at the lower ends of the columns of Morgagni, about ½ inch above the anus. They lie in the lower ends of the longitudinal grooves, where they extend between adjacent columns, and they bear a resemblance to the valves which are met with in veins. They are semilunar folds of the mucous membrane, their free margins being directed upwards, and behind each valve there is a small recess or 'sinus.' The mucous membrane of the anal canal is replaced in the lower third (below the anal valves) by modified skin, continuous with that of the exterior. In the upper two-thirds of the canal the mucous membrane is lined by *columnar epithelium*, and in the upper third it is provided with a few Lieberkühn's crypts and lymphoid nodules. The cutaneous wall of the lower third of the anal canal is covered by *modified epidermic epithelium*, which is continuous at the anal margin with the epidermis. It is at the margins of the anal valves where this modified epidermic epithelium gives place to the columnar epithelium of the mucous membrane, and here also the modified skin of the lower third of the canal becomes continuous with the mucous membrane of the upper two-thirds. The point of transition is indicated by a faint line, which is known as the **white line of Hilton.**

Sphincter Ani Internus.—This so-called muscle is merely a thickening of the *circular* plain muscular fibres of the gut. It is confined to the region of the anal canal, and, viewing it as an independent muscle, or rather thickening of muscular tissue, it begins very near the upper end of the anal canal, and terminates about ½ inch above the anus. Though auxiliary to the external sphincter, the principal action of the internal sphincter is to expel the contents of the anal canal.

Blood-supply of the Rectum and Anal Canal—Arteries.—The rectum and anal canal receive their arterial supply from (1) the superior hemorrhoidal, which is a single vessel, (2) the middle hemorrhoidals, right and left; (3) the inferior hemorrhoidals, right and left; and (4) branches from the middle sacral and sciatic arteries.

The **superior hemorrhoidal artery** is of large size, and is the direct continuation of the inferior mesenteric. Having crossed the left common iliac vessels, it descends within the root of the pelvic meso-colon as low as the third sacral vertebra, where the rectum commences. Here it divides into two branches, right and left, which descend upon the sides of the rectum. From each of these divisions six or more branches are given off, which enter the rectal wall near its centre. Having pierced the muscular coat, they enter the submucous coat, and there subdivide into small terminal branches, which descend in the submucous coat as low as the anal valves, some of them lying within the columns of Morgagni. As these terminal branches descend they give off twigs, which, by anastomosing with branches of the middle and inferior hemorrhoidals, give rise to an arterial anastomotic network in the submucous coat. The disposition of the two primary divisions

of the superior hemorrhoidal artery on the sides of the rectum is to be borne in mind in the performance of Whitehead's operation for the removal of hemorrhoids.

The **middle hemorrhoidal arteries** are two in number, right and left, and are branches of the anterior divisions of the internal iliacs, often arising in common with the inferior vesicals. Having reached the sides of the rectum about its centre, they divide into branches, some of which supply the muscular wall, whilst others enter the submucous coat to take part, along with the superior and inferior hemorrhoidals, in the anastomotic network.

The **inferior hemorrhoidal arteries** are two in number, right and left, and each may be a single artery, or there may be two or three on each side. In any case, they are branches of the internal pudic, immediately after that vessel has taken up its position in Alcock's canal on the outer wall of the ischio-rectal fossa. Having pierced the wall of Alcock's canal, and traversed the fat of the ischio-rectal fossa, they approach the wall of the anal canal, where they break up into branches, some of which supply the muscular wall, including the external sphincter and adjacent fibres of the levator ani, whilst others pass into the submucous coat, where they take part, along with the superior and middle hemorrhoidals, in the anastomotic network already referred to. The middle and inferior hemorrhoidal arteries of one side anastomose with their fellows of the opposite side.

The rectum also receives twigs from the middle sacral and sciatic arteries.

Veins.—The veins, all of which are destitute of valves, form two rich plexuses, internal hemorrhoidal, situated in the submucous coat, and external hemorrhoidal, lying along the exterior of the rectum, both being confined to its lower third. The **internal hemorrhoidal plexus,** situated in the submucous coat, receives its radicles from a set of vessels, termed *anal veins*, which commence beneath the anal integument. These anal veins ascend in the wall of the anal canal, some of them lying within the columns of Morgagni, and they are reinforced by other veins from the anal wall. Having given rise by their communications to the internal hemorrhoidal plexus over the lower third of the rectum, the blood is conveyed away from the plexus in two channels as follows: (1) the veins from the upper part of the plexus pierce the wall of the rectum, and open into the external hemorrhoidal plexus; and (2) the veins from the lower part of the plexus pass through the external sphincter to end in a plexus on the outer surface of that muscle, in which the inferior hemorrhoidal veins originate. The **external hemorrhoidal plexus** is situated on the outer wall of the rectum over its lower third, and is continuous below with the plexus on the outer surface of the external sphincter. It is from this external hemorrhoidal plexus that the hemorrhoidal veins, which correspond with the hemorrhoidal arteries, pass off. The **superior hemorrhoidal vein** leaves the plexus in two divisions right and left, which ultimately join to form one vessel, the destination of which is the *inferior mesenteric vein*. It is, therefore, an indirect tributary of the vena portæ. The **middle hemorrhoidal veins,** right and left, terminate in the *internal iliac veins*. The **inferior hemorrhoidal veins,** right and left, pass to the *internal pudic veins*. Through means of the external hemorrhoidal plexus a free communication is established between the systemic and portal venous channels, and, there being no valves, when the portal circulation is obstructed the condition known as hemorrhoids frequently results.

Lymphatics.—The lymphatics of the rectum and *upper* part of the anal canal pass first to the *rectal glands*, which lie upon the wall of the rectum along the course of the superior hemorrhoidal vessels, and through them to the *sacral glands*, their further destination being the *median lumbar glands*. The lymphatics of the *lower* part of the anal canal are continuous with the cutaneous lymphatics around the anus, and pass to the *inguinal glands* which lie immediately below Poupart's ligament.

Nerves.—These are partly sympathetic and partly spinal. The superior hemorrhoidal artery conducts to the rectum and anal canal the superior hemorrhoidal sympathetic plexus, which is an offshoot from the inferior mesenteric plexus, that in turn coming from the aortic plexus. The middle hemorrhoidal arteries conduct the middle hemorrhoidal sympathetic plexuses, which are offshoots from the pelvic plexuses. The spinal fibres are derived from the third and fourth sacral nerves (sometimes also the second), and they belong to the pelvic splanchnics. They are further derived from the upper two or three lumbar nerves, all in the manner described in connection with the innervation of the bladder. The fibres from the *pelvic splanchnics* carry motor impulses to the longitudinal muscular fibres of the rectum, and inhibitory impulses to the circular fibres; whilst the *sympathetic fibres* are motor as regards the circular fibres, and inhibitory as regards the longitudinal fibres. The anal canal, close to the external sphincter, receives twigs from the inferior hemorrhoidal branch of the pudic nerve.

Development of the Rectum, Anal Canal, and Anus.—The rectum, and that part of the anal canal which lies *above* the anal valves, are developed from the hind-gut. The portion of the anal canal which lies *below* the anal valves, and the anus are developed from that part of the cloacal fossa which lies behind the perineal fold, and which is called the **proctodeum.** The septum between the hind-gut and the proctodeum is composed of the hypoblast of the hind-gut and the epiblast of the proctodeum, and, when this disappears about the third month of intra-uterine life, the intestinal tube and the proctodeum become continuous.

Congenital Deficiencies.—Congenital deficiencies in this part of the body are known as **imperforate anus** or **atresia ani.** The chief forms are as follows: (1) the anal membrane, which separates the proctodeum from the hind-gut, may be persistent. (2) The hind-gut may be deficient in its lower part. (3) The upper part of the anal canal may open into the bladder, vagina, or uterus. (4) The cloaca may remain permanent.

The Female Pelvis.

The female pelvis contains the pelvic colon and rectum, with a few coils of the small intestine; the bladder and urethra; the uterus and vagina; and the uterine appendages connected with the broad ligaments, namely, the Fallopian tubes, the ovaries, with the parovarium or epoöphoron, and paroöphoron (the latter in early life); and the round ligaments of the uterus. The arteries are the same as in the male, with the addition of portions of the ovarian arteries, and the uterine arteries, and the substitution of the vaginal arteries for the inferior vesical arteries in the male. The venous plexuses are hemorrhoidal, vesical, pudendal, ovarian, uterine, and vaginal. The nerve-plexuses peculiar to the female are the uterine, ovarian, and vaginal.

General Position of the Viscera.—The pelvic colon and rectum are situated as in the male pelvis. The bladder lies anteriorly, being situated immediately behind the bodies of the pubic bones,

and the urethra is very closely related to the anterior wall of the vagina. The virgin uterus lies upon the superior surface of the bladder, and the broad ligaments extend from either side of it to the lateral wall of the pelvis. The vagina passes off from the lower end of the uterus, and in its outward course it lies between the base of the bladder and the rectum.

Peritoneum.—The peritoneum is related to the pelvic colon and rectum as in the male. On leaving the rectum at a point fully 3 inches above the anus it passes to the posterior wall of the vagina, which it covers for about its upper fourth. It then mounts upwards over the posterior surface of the supravaginal portion of the cervix uteri and the body of the uterus. On reaching the fundus it turns round to the anterior surface, which it invests as low as the junction of the body and cervix. On leaving the viscus it passes to the upper part of the base of the bladder, whence it extends forwards over the superior surface, which it covers as far as the apex. Its course thereafter is as in the male. Along each lateral border of the bladder the peritoneum is reflected on to the lateral wall of the pelvis. Along either side of the uterus it is reflected on to the lateral wall of the pelvis, and in this manner the broad ligaments are formed. Between the rectum and the upper portion of the posterior wall of the vagina and supravaginal portion of the cervix uteri the peritoneum forms a recess, called the **pouch of Douglas,** which corresponds to the recto-vesical pouch in the male. The mouth of this pouch is bounded on either side by a semilunar peritoneal fold, which extends from the front of the sacrum over the side of the rectum to the cervix uteri. These folds are known as the **sacro-uterine folds,** or **recto-uterine folds of Douglas.** Each fold contains a collection of fibrous and plain muscular tissues, connected on the one hand with the fibrous structures in front of the lower part of the sacrum, and on the other with the cervix uteri. They become continuous with each other over the back of the isthmus uteri (junction of body and cervix), and there they give rise to a transverse ridge, called the **torus uterinus.** The pouch of Douglas is bounded in front by the upper part of the posterior wall of the vagina and the supravaginal portion of the cervix uteri, and behind by the rectum. In front of the uterus the peritoneum gives rise to a small recess, called the **utero-vesical pouch,** the entrance to which is bounded laterally by two folds, called the **utero-vesical folds.** As regards the bladder, the peritoneum forms for it false ligaments as in the male, namely, one superior, two lateral, and two posterior. The latter are simply the utero-vesical folds, and may be regarded not only as posterior ligaments of the bladder, but also as anterior ligaments of the uterus.

Pelvic Fascia.—The parietal pelvic fascia in the female is similar to the corresponding fascia in the male. The visceral pelvic fascia, however, is complicated by the interpolation of the vagina. On either side of the pelvic viscera it divides into four laminæ, as follows: *vesical,* which forms, on either side, the lateral true liga-

ment of the bladder; *vesico-vaginal*, which passes between the bladder and the vagina; *recto-vaginal*, which passes between the vagina and the rectum; and *rectal*, which passes over the sides and posterior wall of the rectum.

Broad Ligaments of the Uterus.—These are also called the *alæ vespertilionis*, from their supposed resemblance to a bat's wings. Each is an extensive fold of peritoneum composed of two layers,

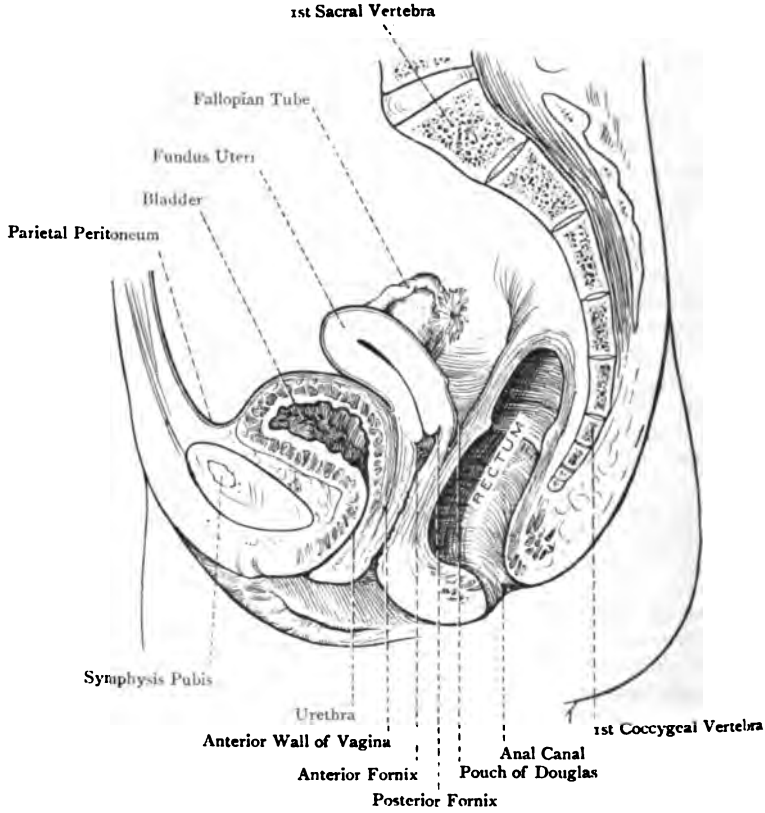


FIG. 358.—VERTICAL SAGITTAL SECTION OF THE FEMALE PELVIS.

anterior and posterior, which pass between the side of the uterus and the lateral wall of the pelvis. The broad ligament has associated with it the following important structures: (1) the Fallopian tube or oviduct, which lies within the superior border of the ligament; (2) the ovary and its ligament, which lie within a backward extension of the posterior layer of the broad ligament at a lower level than the Fallopian tube; (3) the round ligament of the uterus,

which lies within a forward projection of the anterior layer of the broad ligament, also at a lower level than the Fallopian tube; (4) the epoöphoron, which lies within the ligament between the ovary and the Fallopian tube; and (5) the paroöphoron (in early life), which also lies within the ligament, internal to the epoöphoron and near the uterus. The double fold of peritoneum attaching the anterior border of the ovary over its whole length to the back of the broad ligament forms a short mesentery for it, called the **mesovarium,** which contains between its two layers the blood-vessels and nerves of the ovary. The portion of the broad ligament which lies between the Fallopian tube and the ovary with its ligament is called the **mesosalpinx.** It is somewhat falciform, and is narrow internally, but broad externally. It is bounded above by the Fallopian tube, below by the ovary and its ligament, internally by the uterus, and externally by the ovarian fimbria and the suspensory ligament of the ovary.

Round Ligament of the Uterus.—This is a narrow, cord-like band, about 5 inches long, which is attached to the upper part of the side of the uterus in front of, and a little below, the uterine end of the Fallopian tube. It is composed of fibrous connective tissue, which, near the uterus, has an admixture of plain muscular fibres continuous with those of the uterus. It lies within the anterior layer of the broad ligament, where it gives rise to a slight prominence. Its direction is outwards, upwards, and forwards over the obliterated hypogastric artery and pelvic brim to the internal abdominal ring, close to which it hooks round the outer side of the deep epigastric artery, and crosses the external iliac vessels from within outwards. Escaping by the internal abdominal ring, it traverses the inguinal canal, and, emerging through the external abdominal ring, it ends in the subcutaneous tissue of the labium majus. For a short distance after entering the inguinal canal it is covered by a process of the peritoneum, which represents the processus vaginalis in the male fœtus. This process is at first tubular, and receives the name of the **canal of Nuck.** It is usually, however, obliterated in the adult, though it may remain pervious, under which circumstances the condition known as hydrocele of the round ligament may occur. A few muscular fibres may be found in front of the round ligament in the inguinal canal, which are continuous with the lower fibres of the internal oblique, and represent the cremaster in the male.

The round ligament is supplied by two arteries as follows: the ligamentous branch of the ovarian artery, which supplies it as far as the inguinal canal; and the ligamentous branch of the deep epigastric, which supplies it beyond the internal abdominal ring, and corresponds to the cremasteric artery in the male. The principal venous blood is returned by a ligamentous vein, which is a tributary of the ovarian plexus.

The round ligament represents the lower portion of the gubernaculum testis in the fœtal male.

Ovaries.—The ovaries are two small flattened bodies, each of

which lies within a backward extension of the posterior layer of the broad ligament, with which it is connected by the mesovarium. The ovary is laterally compressed, and usually lies, with its long axis vertical, against the lateral wall of the pelvis in a peritoneal depression, called the *ovarian fossa*. It may, however, lie obliquely, and may even be shifted near to the uterus. In size it may be likened to the half of a small walnut, its average length being from 1 inch to 1½ inches, its breadth about ¾ inch, and its thickness (from side to side) from ¼ to ½ inch. Its average

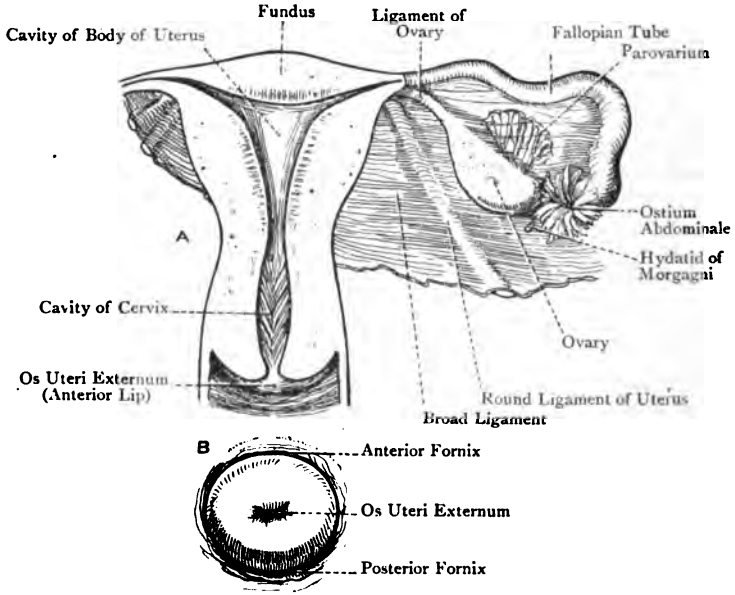


FIG. 359.—THE UTERUS AND ITS APPENDAGES.

A, The Uterus opened, and the Right Broad Ligament (Posterior View); B, The Os Uteri Externum.

weight is about 2 drachms. It presents two surfaces, two borders, and two extremities.

The **surfaces** are laterally disposed, and are called *internal* or *mesial*, which is related to the Fallopian tube, and *external* or *lateral*, which is related to the ovarian fossa. The **borders** are anterior and posterior. The *anterior* or *attached border* is straight. Along it are attached the two layers of the mesovarium, and between these it presents a hilum for the passage of the blood-vessels, nerves, and lymphatics. The *posterior border* is convex and free. The extremities are named **poles**, superior and inferior respectively. The *superior* is named the *tubal pole*, because the

ovarian fimbria is attached to it. Connected with it there is also a fold of peritoneum, which passed upwards to join the peritoneum over the psoas magnus near the upper part of the external iliac vessels. This fold, which is termed the *suspensory ligament of the ovary*, is continuous with the outer part of the broad ligament, and contains the ovarian vessels and nerves. The *inferior* pole is known as the *uterine pole*, and is connected with the superior angle of the uterus by a round cord, called the *ligament of the ovary*. The attachment of this ligament to the uterus is behind and a little below the uterine end of the Fallopian tube.

The surface of the ovary is covered by peritoneum, continuous with the mesovarium, the only exception being along the anterior border, where the hilum exists. The connective-tissue element of this peritoneum is inseparably blended with the so-called tunica albuginea of the ovary, and it is covered by an epithelium the cells of which present a striking contrast to those of the endothelial covering elsewhere. It is composed of *short columnar cells*, and imparts a somewhat dull appearance to the surface, which contrasts with the polished appearance elsewhere. The ovarian epithelium is the remains of the germinal epithelium, from which the ovary is developed, and at the circumference of the organ it passes abruptly into the endothelial cells of the adjacent peritoneum. Prior to puberty the surface of the ovary is smooth, but after that period it gradually assumes a pitted and scarred appearance, which is due to the periodical escape of the ova from the Graafian follicles.

Descent of the Ovary.—The ovary, like the testis, lies originally upon the psoas magnus, below and behind the kidney. At the period of birth it is found lying at the pelvic brim, partly in the iliac fossa and partly in the pelvis.

Abnormal Positions of the Ovary.—(1) The ovary, in its original descent, may pass into the inguinal canal, and even into the labium majus; (2) it may pass through the crural ring into the crural canal, and lie over the saphenous opening, where it may simulate a femoral hernia; (3) an ovary, when enlarged, may become prolapsed, and pass downwards and inwards behind the uterus into the pouch of Douglas, where it may be palpated through the posterior fornix of the vagina.

For the structure and development of the ovary, see p. 836 *et seq.*

Epoöphoron (Parovarium of Kobelt), or Organ of Rosenmüller.—The epoöphoron is situated in that portion of the mesosalpinx which lies between the ovary and the Fallopian tube. It is composed of a number of small blind tubules, lined with epithelium, which converge towards the ovary, but do not meet. Their tubal ends are united by a longitudinal tube, which lies parallel with, and a little below, the Fallopian tube.

Paroöphoron of Waldeyer.—The paroöphoron is situated in that part of the mesosalpinx which lies between the ligament of the ovary and the Fallopian tube, where it is placed near the uterus. It is composed of a few minute blind tubules, which can only be discerned at or shortly after the period of birth.

For the development of the epoöphoron and paroöphoron, see p. 839.

Fallopian Tubes.—The Fallopian tubes, right and left, serve to convey the ova, after their escape from the Graafian follicles, into the cavity of the uterus. They are, therefore, functionally the ducts of the ovaries, and are hence spoken of as the *oviducts*. Each tube is contained within the superior border of the broad ligament, except at its extreme inner end, where the tube is embedded in the uterine wall. It is fully 4 inches in length. Proceeding from the uterus, it passes at first horizontally outwards for about 1 inch towards the lower or uterine pole of the ovary. It then ascends vertically for a short distance upon the lateral wall of the pelvis, where it lies internal to the anterior or attached border of the ovary. Having arrived at the upper or tubal pole, it arches backwards and descends along the posterior convex border, and adjacent portion of the internal surface of the ovary. Each Fallopian tube is divided into the following parts: pars uterina, isthmus, ampulla, neck, and corpus fimbriatum; and each has two openings, ostium uterinum, and ostium abdominale.

The *pars uterina* is the limited portion which is contained within the uterine wall at the superior angle, and it presents the *ostium uterinum*, which is about 1 millimetre in diameter. The *isthmus* succeeds to the pars uterina, and represents about one-third of the tube. It is straight, round, and firm to the touch, due to the predominance of circular muscular fibres in this portion. Its diameter is about 2½ millimetres. The *ampulla* succeeds to the isthmus, and forms rather more than half of the tube. It is larger than the isthmus, less resistant (being chiefly mucous in structure), and tortuous. Its diameter gradually increases in the distal direction, the average being about 7 millimetres. The ampulla at its outer end becomes constricted to form the *neck*, which presents the *ostium abdominale*, opening into the pelvic cavity, its diameter being about 2 millimetres. It is in this situation where the general cavity of the peritoneum in the female is continuous with the lumen of the Fallopian tube, and through it with the cavity of the uterus and vagina. Beyond the neck the tube expands in the form of a funnel, called the *infundibulum* or *pavilion*, in the body of which the ostium abdominale is situated. The circumference of the infundibulum is broken up into a number of irregular fringes, called *fimbriæ*, and the outer end of the tube is hence called the *corpus fimbriatum*. The larger fimbriæ are broken up into smaller filiform processes. The outer surfaces of the fimbriæ, which look into the pelvic cavity, are covered by peritoneum, but the inner surfaces, which look into the infundibulum, are covered by mucous membrane continuous with that of the Fallopian tube. At the free margins of the fimbriæ the peritoneum, with its endothelial cells, becomes continuous with the mucous membrane, which is covered by ciliated columnar epithelium. One of the fimbriæ, which is

larger and longer than the others, is called the *ovarian fimbria*, and is connected with the upper or tubal pole of the ovary usually directly, but sometimes by a delicate fibrous band. This fimbria presents a longitudinal furrow, which serves as a channel of communication between the ostium abdominale and the ovary.

For the structure and development of the Fallopian tubes, see pp. 839 and 842.

Hydatids of Morgagni.—These are small pedunculated cysts, sometimes solitary, which are connected with the fimbriæ, the outer end of the ampulla, or the epoöphoron. They are vestiges of the anterior or cephalic end of the Wolffian duct.

Uterus.—The uterus is a hollow muscular organ, which receives at its superior angles the Fallopian tubes, and opens below into the upper part of the anterior wall of the vagina. Through the Fallopian tubes it receives the ova at periodical intervals, and, when an ovum becomes impregnated, the uterus retains it during development, and thereafter expels the fœtus through the vagina. The virgin uterus lies upon the superior surface of the bladder, and is usually inclined to the right of the middle line. Above it there are a portion of the pelvic colon and usually a few coils of the ileum. At its lower end is the vagina, and the broad ligament stretches from either side. It is somewhat pyriform, the wide end being directed upwards and forwards, and is flattened from before backwards. It is firm and resistant to the touch, on account of its very thick muscular walls. Its average length is 3 inches, the breadth at the upper part being 2 inches, and the thickness 1 inch. The organ is divided into a fundus, body, and cervix.

The **fundus** is that portion which lies above the level of a line connecting the superior angles, where the Fallopian tubes pass through the uterine wall. It is convex from side to side, and also from before backwards. The lateral borders of the uterus are sloped downwards and inwards, and at the junction of the upper two-thirds and lower third of the organ there is a slight constriction or concavity, called the *isthmus*, which is also present in front and behind, and is most conspicuous in early life. The part between the fundus and the isthmus is the body, and the part below the isthmus is the cervix.

The **body,** which is 2 inches long, is triangular, and presents two smooth surfaces, anterior and posterior, and two lateral borders. The *anterior* or *vesical surface*, which has an inclination downwards, is slightly convex. The *posterior* or *rectal surface*, which has an inclination upwards, is more markedly convex. Each *lateral border* extends from the superior angle to the isthmus, and is sloped downwards and inwards. The *superior angles* are situated at the points of entrance of the Fallopian tubes, and correspond with the portions of the uterus which are elongated into cornua in some animals.

The **cervix,** which measures 1 inch in length, is cylindrical, and narrower than the body. It is received into the upper part of the anterior wall of the vagina, the walls of which are at-

tached to it in such a manner as to divide it into two portions—supravaginal and vaginal. The posterior wall of the vagina extends higher upon the cervix behind than the anterior wall does in front. The anterior surface of the supravaginal portion, which is about ½ inch in extent, is related to the base of the bladder, with the intervention of some loose cellular tissue. The posterior surface of the supravaginal portion, which is about ¼ inch in extent, forms a part of the anterior wall of the pouch of Douglas, and is crossed transversely by the torus uterinus. At the lower end of the vaginal portion, where the cervix is slightly protuberant, there is an opening, called the **os uteri externum,** through which the cavity of the cervix communicates with that of the vagina. This opening is also known as the *os tincæ*, because it is supposed to resemble the mouth of the tench fish, on account of its lips being of unequal size. In early life this opening is circular, but later, in the virgin, it assumes the form of a transverse slit about $\frac{1}{12}$ inch long. It is bounded by two lips, anterior and posterior, which in the virgin are smooth, but in multiparæ they are often more or less fissured, especially the posterior lip. The *anterior lip* is thick, round, and short, whilst the *posterior* is thin, sharp, and long. The anterior lip descends lower into the vagina than the posterior, by reason of the oblique manner in which the cervix uteri passes into the canal. It is the anterior lip which first meets the finger in making vaginal examinations. The greater length of the posterior lip is due to the fact that the posterior wall of the vagina extends higher on the back of the cervix than the anterior wall does in front. The os uteri externum is directed downwards and backwards towards the posterior wall of the vagina, this being due to the oblique position of the cervix.

Surrounding the vaginal portion of the cervix there is a vaulted recess, which is divided into anterior, posterior, and lateral **fornices.**

General Relations of the Uterus.—The anterior surface of the body rests upon the superior surface of the bladder, and the anterior surface of the supravaginal portion of the cervix is related to the base of the bladder. The lateral relations are the Fallopian tubes, round ligaments, ligaments of the ovaries, broad ligaments, and a certain amount of adipose tissue, containing large bloodvessels, which lies upon either side of the cervix, and extends upwards over the lateral border between the layers of the broad ligament. This collection is known as the **parametrium.** The posterior surface of the body is related to the rectum, and the posterior surface of the supravaginal portion of the cervix forms a part of the anterior boundary of the pouch of Douglas.

Peritoneal Relations.—The following parts of the uterus are covered by peritoneum: the supravaginal portion of the cervix posteriorly, the posterior surface of the body, the fundus, and the anterior surface of the body as low as the front of the cervix. The following parts are free from peritoneal covering: the vaginal portion of the cervix, the supravaginal portion of the cervix

anteriorly, and a narrow strip along each lateral border where the two layers of peritoneum pass off to form the broad ligament. The uterine peritoneal folds are as follows: two utero-vesical, sometimes called the anterior uterine ligaments, but they may also be regarded as the posterior false ligaments of the bladder; the sacro-uterine folds, with the torus uterinus; and the broad ligaments.

Position of the Uterus.—The virgin uterus occupies a position of anteflexion and anteversion, assuming the bladder and rectum to be empty. In speaking of the uterus as being *anteflexed* it is to be understood that the body of the organ is bent forwards at the isthmus in such a manner that it forms with the cervix an angle, which is open anteriorly. This is brought about in the following manner: the cervix uteri is more fixed than the body, from its connection with the vaginal walls and base of the bladder; and the cervix is less yielding than the body. In speaking of *anteversion* of the uterus it is to be understood that the entire uterus is inclined forwards, so that its long axis forms an angle with the longitudinal axis of the trunk. The anterior surface has therefore a downward inclination towards the superior surface of the bladder, and the posterior surface has an upward inclination, and so supports a portion of the pelvic colon and a few coils of the ileum. When the bladder is distended, the position of the uterus becomes altered. The organ is raised along with the distended bladder, the anteflexion and anteversion become less, and the uterus may even assume a vertical position. Any coils of the ileum lying in contact with its posterior surface, as well as the pelvic colon, would be displaced, and the organ would come to be closely related to the rectum.

Interior of the Uterus.—The interior is divided into two portions,—the cavity of the body and the cavity of the cervix. The *cavity of the body* is very small compared with the thickness of the uterine walls, and is triangular, with the base directed upwards towards the fundus. Its three sides are convex towards the cavity, and its anterior and posterior walls are in contact. In the vicinity of each superior angle it narrows, and gradually tapers to the ostium uterinum of the Fallopian tube, with the lumen of which it is continuous. Inferiorly the cavity also becomes narrow, and, at the junction of the body and cervix, it ends in a circular opening, called the **os uteri internum,** which is smaller than the os externum. Through this opening it becomes continuous with the cavity of the cervix. The *cavity of the cervix* is spindle-shaped, being wider at the centre than at either end. It is somewhat flattened from before backwards, and is continuous above with the cavity of the body through the os internum, and below with the cavity of the vagina through the os externum. Its mucous membrane presents two longitudinal ridges, anterior and posterior, from each of which a number of rugæ extend in an upward and outward direction, the appearance thus produced being known as the *arbor vitæ uterina*, or *plicæ palmatæ*.

Uterus at Birth.—At birth the neck of the uterus is larger than the body, and there is no fundus. At each superior angle it tapers very much, and resembles somewhat a uterus bicornis. The arbor vitæ uterina extends all along the interior.

Varieties.—These are as follows: (1) uterus bicornis; (2) uterus unicornis; and (3) double uterus.

For the structure and development of the uterus, see pp. 840 and 842.

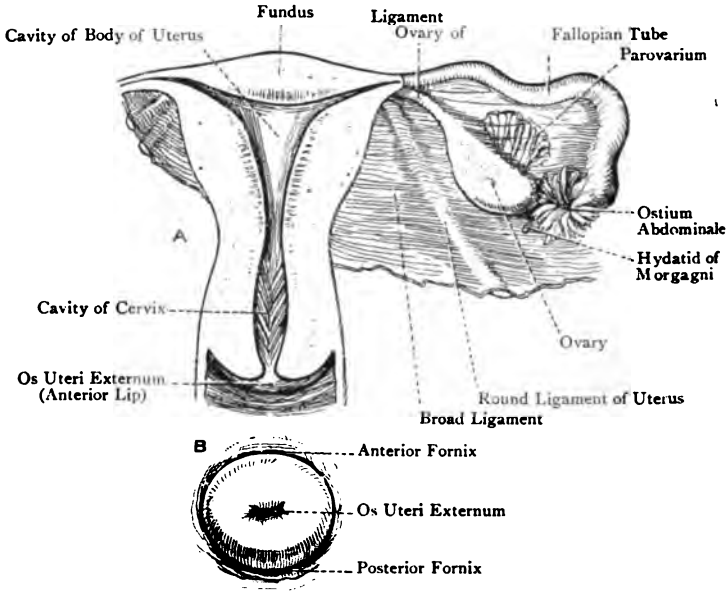


FIG. 360.—THE UTERUS AND ITS APPENDAGES.

A, The Uterus opened, and the Right Broad Ligament (Posterior View); B, The Os Uteri Externum.

Vagina.—This is a musculo-membranous passage which extends from the cervix uteri to the vulva. It is from 3 to 3½ inches long, being 3 inches along the anterior wall, and 3½ inches along the posterior. It is slightly curved, and its direction is downwards and forwards. Its axis forms an obtuse angle with that of the uterus (100° to 110°). In the erect posture it forms with the horizontal an angle of about 60°. Superiorly it is closely connected with the cervix uteri, the posterior wall rising higher than the anterior. It is rather narrower at either end than at the centre, the lower end being the narrowest part of the passage. The walls are anterior and posterior, and they are in contact. In transverse section the vagina appears as an H-shaped fissure at its

lower end, as a transverse fissure at the centre, and at its upper end it presents a lumen which is almost circular.

Relations—*Anterior.*—The base of the bladder, and the urethra. *Posterior.*—From above downwards there are the pouch of Douglas for a short distance, the rectum, with the intervention of the recto-vaginal lamina of the visceral pelvic fascia, and the anal canal, from which it is separated by the perineal body. The posterior wall is covered by peritoneum over about its upper fourth. *Lateral.*—The ureter at the upper end for a short distance, and the levatores ani muscles.

The vagina passes through the triangular ligament, and its lower end has a bulbus vestibuli on either side, with the sphincter vaginæ surrounding the external orifice. When the finger is passed into the posterior fornix, which is the recess between the posterior lip of the os uteri externum and the posterior wall of the vagina, the pouch of Douglas can be palpated, and a few coils of the ileum, or a prolapsed ovary, may be felt in it. The base of the bladder may be palpated through the anterior fornix, and the urethra through the anterior wall of the vagina lower down.

For the structure and development of the vagina, see p. 842.

Bladder.—The base is directed backwards, and is related to the front of the supravaginal portion of the cervix uteri and a portion of the anterior wall of the vagina, the utero-vesical pouch of the peritoneum intervening. The superior surface is in contact with the anterior surface of the body of the uterus. The false ligaments, formed by the peritoneum, are at least three in number, namely, one superior and two lateral. The peritoneal folds on either side of the utero-vesical pouch are usually regarded as the anterior uterine ligaments, but they may also be looked upon as the posterior false ligaments of the bladder. The true ligaments are similar in both sexes.

Ureters.—Each ureter lies for a short distance on the side of the cervix uteri and upper part of the wall of the vagina, being crossed near the cervix by the uterine artery.

Urethra.—The urethra is very closely related to the anterior wall of the vagina. Its length is 1½ inches, and its transverse diameter is about ¼ inch, the narrowest part being at the meatus urinarius. The direction of the canal is downwards and forwards, and its walls are anterior and posterior, these being in contact except during micturition. In its course it passes between the two layers of the triangular ligament, where it is embraced by the compressor urethræ muscle. The canal is capable of considerable distension, and may, under anæsthetics, admit the index-finger. The *meatus urinarius* is situated at the posterior extremity of the vestibule in the middle line, immediately in front of the external orifice of the vagina, and is placed on a slight prominence, the margins of which are somewhat irregular.

For the structure and development of the urethra, see p. 843.

Rectum—Relations—*Anterior.*—The uterus and vagina, the recto-vesical pouch of Douglas intervening for a short distance in the vicinity of the cervix uteri. *Posterior.* — As in the male.

Anal Canal.—This is separated from the vagina by the perineal body.

Ovarian Artery in the Pelvis.—This vessel, which arises from the abdominal aorta about 1 inch below the renal artery, enters the pelvis by crossing the commencement of the external iliac. It then passes within the broad ligament of the uterus, where it is very tortuous, and its branches to the ovary enter that organ through the hilum on the anterior border without piercing the peritoneum. Besides supplying the ovary the vessel furnishes the following branches: *uterine* to the uterus, near the superior angle, where it anastomoses with branches of the uterine artery from the internal iliac; *tubal* to the Fallopian tube; and *ligamentous* to the round ligament of the uterus, which accompanies it as far as the inguinal canal.

The **ovarian vein** of each side originates as two vessels in the **ovarian** or **pampiniform plexus,** which lies within the broad ligament. This plexus receives the veins which emerge through the hilum of the ovary, as well as tributaries from the Fallopian tube and round ligament of the uterus, and it communicates freely with the uterine plexus. The two ovarian veins, having emerged from the ovarian plexus, leave the pelvis, and soon join to form a single vein, that of the *right* side opening into the inferior vena cava, and that of the *left* side into the left renal vein.

Uterine Artery.—This vessel is derived from the anterior division of the internal iliac artery. It is directed downwards and inwards to the side of the cervix uteri, near which it crosses the ureter. On reaching the cervix it turns upwards along the lateral border of the body in a very tortuous manner, lying between the two layers of the broad ligament. As it ascends it gives off tortuous branches to the front and back of the body, and near the inner end of the Fallopian tube it anastomoses with the uterine branch of the ovarian artery. Along the side of the body it also gives offsets to the round ligament, ligament of the ovary, and Fallopian tube. At the cervix the uterine artery furnishes two branches—cervical and vaginal. The *cervical branch* supplies offsets to the cervix. One of these, called the *coronary artery*, divides into two branches, which with their fellows of the opposite side form an arterial circle around the cervix. The *vaginal branch* divides into two, anterior and posterior, which descend in the middle line of the anterior and posterior walls of the vagina, where they anastomose with branches of the vaginal arteries.

The **uterine veins,** which are destitute of valves, form a copious plexus within the broad ligament close to the uterus, where it is embedded in the parametrium. The blood from the lower part

of this plexus is conveyed away by two uterine veins, which are tributaries of the internal iliac vein. A large proportion of the blood, however, passes from the upper part of the plexus into the ovarian plexus. The uterine plexus communicates below with the vaginal plexus.

Vaginal Artery.—This vessel, which usually replaces the inferior vesical of the male, arises from the anterior division of the internal iliac, occasionally in common with the uterine, or the middle hemorrhoidal, artery. It passes downwards and inwards to the wall of the vagina, where it divides into branches which anastomose with their fellows of the opposite side, the vaginal branches of the uterine

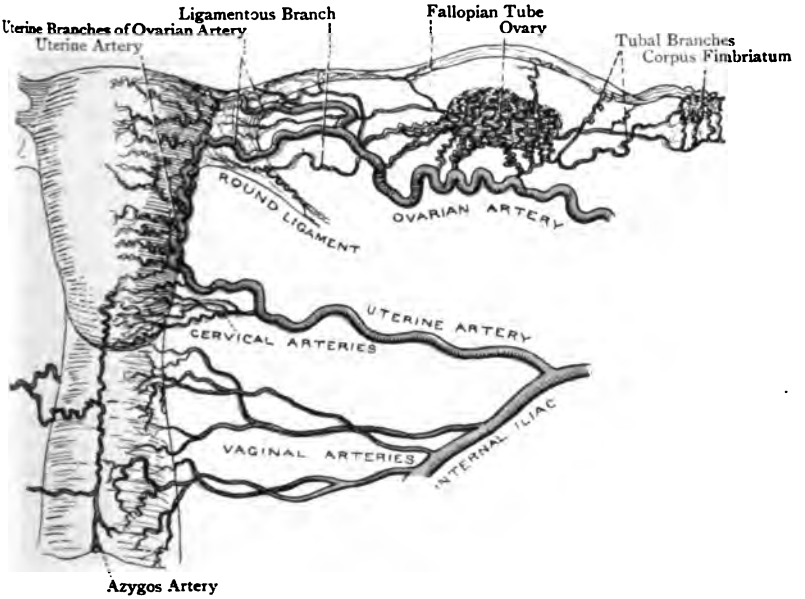


FIG. 361.—THE OVARIAN, UTERINE, AND VAGINAL ARTERIES. (POSTERIOR VIEW) (AFTER HYRTL).

arteries, and, towards the lower end of the vagina, with branches of the internal pudic. Along the anterior and posterior walls, in the median line, an arterial chain is constructed by the vaginal arteries and the vaginal branches of the uterine arteries, thus forming the vessels known as the *vaginal azygos arteries*. The vaginal artery also furnishes branches to the bladder, rectum, and bulbus vestibuli.

The veins of the vagina form a rich plexus in the muscular coat, which is more copious towards the lower end. They communicate above with the uterine plexus, in front with the pudendal plexus

around the urethra, behind with the hemorrhoidal plexus, and below with the veins of the bulbus vestibuli. The **vaginal vein** leaves the upper part of the vaginal plexus and opens into the internal iliac vein.

THE STRUCTURE OF THE SPECIAL VISCERA OF THE FEMALE PELVIS.

The Ovaries.

The ovary is covered by a layer of short columnar epithelial cells. These are the remains of the germinal eptihelium from which the organ is developed, and they rest upon a delicate, connective-tissue membrane, which is blended with the so-called tunica albuginea. Interposed between the columnar cells there are a few spheroidal cells of larger size, which are primordial ova. The connective-tissue membrane is continuous with the peritoneum which forms the mesovarium along the margins of the hilum, and which is covered by endothelium. Within this membrane, and blended with it, there is a continous covering, consisting of fibrous connective tissue, which is called the *tunica albuginea ovarii*, from its supposed resemblance to the tunica albuginea testis. It is, however, really a condensation of the ovarian stroma at the surface. This stroma pervades the interior of the ovary, and is composed of fibrous connective tissue, which is richly provided with spindle-shaped cells and elastic tissue. There are also a few plain muscular fibres in the deeper part of the ovary close to the hilum. The spindle-shaped cells are regarded by some authorities as muscular fibre-cells, but they probably belong to the connective tissue of the stroma. The stroma is freely permeated by bloodvessels, and contains the Graafian follicles. Immediately within the surface there is a layer of the stroma which presents a granular appearance, especially in young persons, due to the presence of an immense number of Graafian follicles, with their contained ova, in an early stage. This part of the ovary is called the *cortex*, the remainder being known as the *medulla*. Lying more deeply in the stroma there is another set of Graafian follicles, less numerous, but of larger size, these being in a more advanced stage. Still more deeply there is another and less numerous set of follicles, of still larger size, which are almost in a state of maturity. When these latter have attained full development, they pass towards the surface, where they may sometimes be seen as clear follicles causing slight projections. When fully developed, they attain a diameter of about $\frac{1}{2}$ inch. At periodical intervals one or more of these mature follicles rupture, this being accompanied by the discharge of a fluid—the liquor folliculi—and the simultaneous escape of the contained ovum or ova. After the discharge of its contents the follicle becomes filled with blood and cellular tissue, and assumes a yellow colour.

It is then known as a *corpus luteum*. This undergoes atrophy in the virgin, and, assuming a white colour, is known as a *corpus albicans*.

Structure of the Graafian Follicles.—The smallest follicles near the surface, which are about $\frac{1}{100}$ inch in diameter, consist of a single investing layer of flattened cells, closely embracing the contained ovum. It is computed that the ovaries of a child at birth contain as many as 70,000 of these follicles. In follicles a little more advanced the investing epithelium becomes columnar, and is arranged in two layers—outer and inner, the latter surrounding the ovum. In more mature follicles fluid, called the *liquor folliculi*,

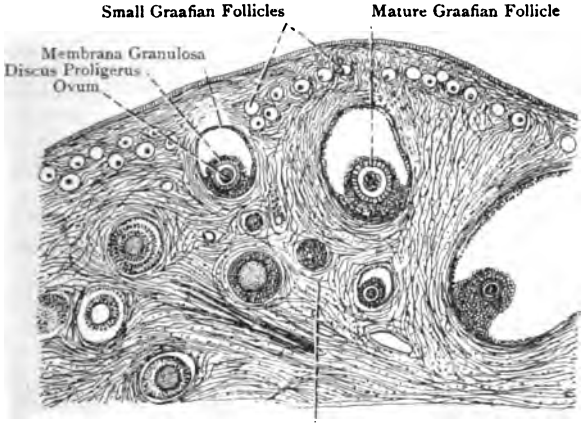


FIG. 362.—SECTION OF THE OVARY, SHOWING ITS MINUTE STRUCTURE.

accumulates between the outer and inner cellular layers, except at the point where the ovum lies. The outer layer is then known as the **membrana granulosa,** and the inner as the **discus proligerus.** The cells of these two layers become continuous at the part where the liquor folliculi is absent, so that in this manner the ovum is anchored to one point of the wall of the follicle. In the most mature follicles the liquor folliculi has increased in amount, and the cells of the membrana granulosa and discus proligerus have multiplied so as to form several strata. Each of these follicles has a distinct wall, called the *theca folliculi*, which is formed by a condensation of the surrounding stroma, and in which two layers can be recognised—an outer fibrous and an inner vascular. There is usually only one ovum in each follicle.

Structure of the Ovum.—The ovum is a spherical cell, having a diameter of about $\frac{1}{125}$ inch. It has two membranes—an external, called the **zona radiata** (zona pellucida), and an internal, called the **vitelline membrane,** the latter representing the cell-wall. Within

this is the cell-body, called the **yolk**, or **vitellus,** which contains a nucleus, known as the **germinal vesicle,** and that in turn contains a nucleolus, called the **germinal spot.** The zona radiata is fairly thick, and is perforated by pores or canals, arranged in a radiating manner, hence the name 'radiata.' These canals serve for the passage of nutritive material, and also for spermatozoa preparatory to impregnation. The vitelline membrane is merely a condensation of the yolk at the surface. The yolk, or vitellus, is semifluid, very refracting, and contains many yolk granules, which are fatty and albuminoid in their nature. These granules form the *nutritive yolk*, or *deutoplasm*, the remainder of the yolk being called the *formative yolk*, or *cytoplasm*. The nucleus or germinal vesicle is about $\frac{1}{300}$ inch in diameter. It is eccentric in position in the cytoplasm, and has the usual characters of a cell-nucleus. The nucleolus, or germinal spot, is granular in character.

Blood-supply of the Ovary.—The ovary receives its blood from the ovarian artery.

Nerves.—These come from the ovarian sympathetic plexus, which derives its fibres from the renal and aortic plexuses, and accompanies the ovarian artery.

Lymphatics.—The lymphatics of the ovary, along with those of the upper part of the uterus, pass to the *median lumbar glands*.

The ovaries represent the testes in the male, and they have been called the *testes muliebris*.

Ligament of the Ovary.—This is composed of plain muscular and fibrous tissues, the former being continuous with the muscular tissue of the uterus. It derives its blood-supply from the ovarian artery, and represents the upper part of the gubernaculum testis in the male fœtus.

Development of the Ovary.—The ovary, like the secreting tubules of the testis, is developed from the germinal epithelium and genital ridge. The **germinal epithelium** is developed from the peritoneal epithelium on the inner side of the Wolffian body, which latter epithelium undergoes a thickening and segmentation. This germinal epithelium covers a ridge of mesoblast, called the **genital ridge.** In the development of the ovary the germinal epithelium becomes much thickened, and some of the more deeply placed cells in the course of the second month invade the mesoblast of the genital ridge, where they become enlarged, and lie at first isolated in its mesoblastic connective tissue. These cells are the primordial ova. Other cells of the germinal epithelium now invade the genital ridge, where they arrange themselves in circular groups or 'cell nests' around the primordial ova. In this manner the primordial Graafian follicles are formed. The primordial ovum in the centre of each cell-nest represents the ovum of the mature Graafian follicle, the cells surrounding it represent the cells of the mature follicle, and the adjacent mesoblastic connective tissue represents the capsule of the follicle. From this period (second month) up to the seventh month other cells of the germinal epithelium continue to invade the genital ridge, where they at first form cell-columns, called the **egg-tubes of Pflüger.** At the same time bands of the mesoblastic connective tissue of the genital ridge between the egg-tubes invade the germinal epithelium, and this intermingling of egg-tubes and connective-tissue bands, together with the primordial Graafian follicles, gives rise to the ovary. The egg-tubes now break

up and form other cell-nests, and one cell of each nest in the centre becomes an ovum. These fresh cell-nests, with their contained ova, form other Graafian follicles. Sometimes two or three ova are formed within a cell-nest. The capsular investment of the ovary is developed from the meso-blastic connective tissue of the genital ridge, which becomes condensed at the surface to form an external tunic. The permanent epithelium of the ovary is developed from the surface cells of the germinal epithelium which have not taken part in the formation of the ova and egg-tubes. The cells of this epithelium differ in a marked manner from those of the adjacent peritoneum inasmuch as they are *columnar*, whilst the cells of the adjacent peritoneum are the usual *flattened endothelial cells* of a serous membrane.

Summary.—The Graafian follicles, with their contained cells and ova, are developed from the cells of the germinal epithelium. The capsules of the follicles and the external tunic of the ovary are developed from the meso-blastic connective tissue of the genital ridge. The permanent epithelium, which covers the surface of the ovary, and is composed of short columnar cells, is developed from the surface cells of the germinal epithelium which have not taken part in the formation of the Graafian follicles.

Development of the Epoöphoron.—The **longitudinal tube,** which lies parallel to the Fallopian tube, is a persistent part of the Wolffian duct, and represents the canal of the epididymis in the male. In some animals, *e.g.*, the sow, the Wolffian duct remains persistent, and, under the name of the *duct* or *canal of Gärtner*, can be traced from the broad ligament of the uterus along the side of that organ to the lateral wall of the vagina in its upper part, where it disappears. In the human female it sometimes takes a similar course, and the portion of it on the uterine and vaginal walls is to be regarded as representing the vas deferens in the male. When a persistent Wolffian duct takes this course in the human female, it is sometimes spoken of as the duct of Gärtner. The **transverse tubules** of the epoöphoron, extending from the region of the ovary to the longitudinal tube (so-called duct of Gärtner), into which they open at right angles, are vestiges of the anterior segmental tubes of the Wolffian body, and represent the vasa efferentia and coni vasculosi of the testis in the male.

Development of the Paroöphoron.—These vestigial tubules are derived from the more posterior segmental tubes of the Wolffian body, and they represent the paradidymis or organ of Giraldés in the male.

Structure of the Fallopian Tubes.

The wall of the **Fallopian tube** is composed of four coats—serous, muscular, submucous, and mucous. The **serous coat** is formed by the peritoneum. The **muscular coat** is composed of plain muscular tissue, arranged as an *outer longitudinal* and *inner circular layer*, the latter being the thicker. The **submucous coat** is areolar in structure. The **mucous coat** is continuous with that of the uterus on the one hand, and with the peritoneum on the other, at the margins of the fimbriæ. It is thrown into longitudinal folds, which are simple in the isthmus, but complex in the ampulla, where they are beset with secondary folds, and communicate in such a manner as to give rise to alveolar spaces, thus imparting an almost glandular appearance to the coat. In transverse section the tube presents a branched lumen, which is nearly filled by the leaf-like processes formed by the mucous folds. The mucous membrane is covered by ciliated columnar epithelium, which, at the free margins of the fimbriæ, passes into the endothelium of the peritoneum.

Blood-supply.—The ovarian and uterine arteries.

Nerves.—These are derived from the ovarian and uterine sympathetic plexuses.

Lymphatics.—These pass to the *median lumbar glands* along with those of the ovary and upper part of the body of the uterus.

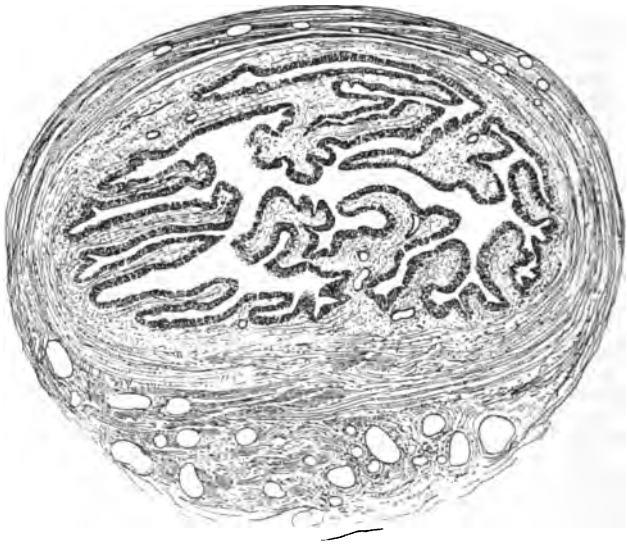


FIG. 363.—TRANSVERSE SECTION OF THE FALLOPIAN TUBE (HIGHLY MAGNIFIED).

Structure of the Uterus.

The wall of the uterus consists of three coats—serous, muscular, and mucous—there being no submucous coat.

The **serous coat** is formed by the peritoneum, already described.

The **muscular coat** is composed of plain muscular tissue, with an admixture of areolar tissue, and it imparts great thickness to the wall. The muscular tissue is disposed in three strata—outer, middle, and inner. The *outer stratum* is thin, and its fibres are disposed longitudinally over the front and back of the organ, becoming continuous with one another by turning over the fundus. Those nearest the lateral borders incline outwards, and are prolonged into the round ligaments, Fallopian tubes, and ligaments of the ovaries. Some from the back of the supravaginal portion of the cervix are prolonged into the sacro-uterine folds. The *middle stratum* is very thick, and is composed of fibres which interlace in a complex manner over the body, but in the neck they are arranged circularly. The bloodvessels and nerves are freely interspersed

throughout this layer. The *inner stratum*, which is also very thick, has its fibres disposed longitudinally in the cervix. As they ascend over the body they become oblique, and at the superior angles they run circularly. The uterine glands project into this stratum, and it contains a free admixture of areolar tissue. It is right to mention that the inner stratum is regarded as a very much thickened muscularis mucosæ, according to which view it would form a part of the mucous coat (Williams).

The **mucous membrane** of the *cavity of the body* is smooth, and soft in consistence, and is covered by ciliated columnar epithelium. It is beset with a number of openings, which are the mouths of the **uterine** or **utricular glands.** These are simple tubular glands, which extend in a somewhat convoluted manner through the entire thickness of the mucous coat, and project by their deep blind ends into the inner muscular stratum, there being no submucous coat. Each gland is composed of a basement membrane, which is lined with ciliated columnar epithelium, continuous with that of the cavity of the body. Each has a distinct lumen, except at its deep end, where it is filled with cells. The mucous membrane of the *cavity of the cervix* is of firmer consistence than that of the cavity of the body, and, as has been stated, it presents the appearance known as the arbor vitæ uterina. It is provided with papillæ, and is covered by *columnar epithelium*, except near the os externum, where the epithelium is of the *stratified squamous* variety, as it is over the exterior of the vaginal portion of the cervix and vagina. On the summits of the rugæ the columnar cells are ciliated, but in the furrows between them they are devoid of cilia. The mucous membrane is freely provided with **racemose glands,** which in the upper part of the cervix are lined with columnar cells, and in the lower part with cubical cells. In both regions the cells are non-ciliated. The glands in the lower part of the cervix have each a large lumen, and they secrete a very tenacious mucus during pregnancy, which, in the later stages of that period, plugs the os externum.

In addition to these glands clear vesicles of a yellowish colour, called the **ovula Nabothi,** may be seen in the mucous membrane between the rugæ of the arbor vitæ uterina, which are supposed to result from the closure of some of the racemose glands.

Blood-supply.—The uterus is supplied with blood by the uterine arteries, and the uterine branches of the ovarian arteries.

Nerves.—The chief nerves are derived from the uterine sympathetic plexus, which is an offshoot from the pelvic plexus, and accompanies the uterine artery. It is to be noted that the pelvic plexus contains spinal fibres derived from the third and fourth sacral nerves (sometimes also the second), and from the upper two or three lumbar nerves, as in the case of the bladder and rectum. The uterus also receives sympathetic fibres from the ovarian plexus, which is derived from the renal and aortic plexuses.

Lymphatics.—These are very numerous, and form superficial and

deep sets. Those from the cervix and adjacent portion of the body pass to the *internal iliac glands*, whilst those from the upper portion of the body pass, with those of the ovaries and Fallopian tubes, to the *median lumbar glands*.

Structure of the Vagina.

The wall of the vagina is composed of three coats—fibrous, muscular, and mucous.

The **fibrous coat** is composed of dense connective tissue.

The **muscular coat** consists of plain muscular tissue, arranged as an *outer longitudinal* and *inner circular layer*, both being closely connected. Embedded in this coat there is a network of anastomosing veins, representing erectile tissue, which is well developed round the lower part of the passage. The plain muscular coat is replaced at the external orifice by the striated sphincter vaginæ muscle.

The **mucous membrane** is covered by stratified squamous epithelium, and is provided with papillæ. In the upper part of the passage it contains mucous glands. Along the middle line of the anterior and posterior walls it presents a ridge, these ridges being called the **columns** of the vagina, or *columnæ rugarum*. Passing off from them at right angles there are, in the virgin, numerous transverse rugæ, these appearances being well marked in the lower part of the passage, and absent in the upper part.

Blood-supply.—The vagina is supplied with blood by the vaginal arteries, the vaginal branches of the uterine arteries, and branches of the internal pudic arteries.

Nerves.—These are derived from the vaginal sympathetic plexus of each side, which is an offshoot from the pelvic plexus.

Lymphatics.—These form two networks, one in the mucous coat, and the other in the muscular coat, which communicate with each other. The lymphatics from the upper two-thirds pass to the *internal iliac glands*, whilst those from the lower third go to the *inguinal glands*.

Development of the Fallopian Tubes, Uterus, and Vagina.—These structures are developed from the Müllerian ducts, which appear shortly after the Wolffian ducts. Each Müllerian duct is developed from a part of the germinal epithelium. At first it takes the form of a solid longitudinal cord, which subsequently acquires a lumen, and it lies upon the outer side of, and parallel to, the corresponding Wolffian duct. The Müllerian ducts open by their anterior or cephalic ends into the cœlom or body-cavity. On being traced backwards they cross the Wolffian ducts and lie on their inner sides. They then enter the genital cord, which is a collection of connective tissue enclosing the Wolffian ducts as they pass to the cloaca. Within the genital cord the Müllerian ducts unite about the fourth month, and form one duct or canal, which occupies the median line. This duct finally opens into the lower portion of the ventral or uro-genital compartment of the cloaca, which subsequently forms the uro-genital sinus, its opening being in the median line between the openings of the Wolffian ducts. The anterior or cephalic parts of the Müllerian ducts retain permanently their openings into the cœlom or body-cavity, which are somewhat funnel-shaped, and these anterior parts give rise to the Fallopian tubes.

The tube or canal formed by the union of the posterior parts of the Müllerian ducts forms the uterus and the vagina.

In the male the only vestiges of the Müllerian ducts which are met with are the sinus pocularis (uterus masculinus) of the prostatic urethra, and the hydatids of Morgagni of the testis.

The abnormal condition of the uterus known as *uterus bicornis* (two-horned uterus) is due to the fact that the union of the two Müllerian ducts sometimes takes place lower down than usual. The condition known as *uterus unicornis* is due to imperfect development of one Müllerian duct. In extremely rare cases these ducts fail to unite, and, by opening independently into the uro-genital sinus, they give rise to a double uterus and double vagina. In the male the tube formed by the union of the posterior ends of the Müllerian ducts forms the sinus pocularis (uterus masculinus), which thus represents the uterus and vagina (Banks).

Structure of the Urethra.

The wall of the urethra is composed of three coats—muscular, vascular, and mucous. The **muscular coat,** which is continuous with that of the bladder, is composed of plain muscular tissue, arranged as an *outer circular* and an *inner longitudinal* layer. The circular fibres are well developed, especially at the upper end, where they partake somewhat of the nature of a sphincter muscle. Superficial to the circular fibres the urethra, as it lies between the two layers of the triangular ligament, is embraced by the striated fibres of the compressor urethræ. The **vascular coat** is composed of a rich plexus of veins, supported and pervaded by areolar and elastic tissues. This plexus is continuous above with that around the neck of the bladder. The **mucous coat** is covered by *transitional epithelium* in its upper part, and *stratified squamous epithelium* in its lower part. It is provided with papillæ, and is thrown into longitudinal folds, which are temporary above, but permanent below. One fold, situated on the posterior wall, is larger than the others, and is known as the **crest.** The mucous membrane is furnished with tubular mucous glands, and between the permanent folds in the lower part there are crypts or lacunæ.

The **lymphatics** of the urethra pass to the *inguinal glands.*

Development of the Urethra.—The female urethra is developed from the anterior or cephalic end of the ventral or uro-genital compartment of the cloaca, which also gives rise to the bladder. It represents the prostatic portion of the male urethra as low as the sinus pocularis or uterus masculinus.

The Articulations of the Pelvis.

Lumbo-sacral Articulation.—The union between the fifth lumbar vertebra and the base of the sacrum is effected by means of the following ligaments: an intervertebral disc, prolongations of the anterior and posterior common ligaments of the bodies of the vertebræ above, capsular ligaments and synovial membranes for the articular processes, ligamenta subflava for the laminæ, and interspinous and supraspinous ligaments for the spinous processes. These are similar to the corresponding ligaments above the level

of the fifth lumbar vertebra. The articulation between the bodies of the fifth lumbar and first sacral vertebræ belongs to the class **amphiarthrosis,** and the joints between the articular processes belong to the class **diarthrosis,** and the subdivision **arthrodia.** In addition to the foregoing ligaments there are two special ligaments, called lateral lumbo-sacral and ilio-lumbar. The **lateral lumbo-sacral ligament,** at either side, extends from the lower aspect of the transverse process of the fifth lumbar vertebra anteriorly to the upper surface of the ala of the sacrum at its anterior and outer part close to the sacro-iliac articulation. It is somewhat fan-shaped, and corresponds to the intertransverse ligaments of the lumbar vertebræ, and the superior costo-transverse ligaments of the thoracic region. The **ilio-lumbar ligament** extends from the tip of the transverse process of the fifth lumbar vertebra to the inner lip of the iliac crest, where it is attached for about 2 inches above the back part of the iliac fossa. It is triangular, and its direction is outwards and slightly backwards. It is closely associated with the lower part of the anterior lamina of the lumbar aponeurosis.

Arterial Supply.—Ilio-lumbar and superior lateral sacral arteries.

Nerve-supply.—Fourth and fifth lumbar nerves, and sympathetic filaments.

Movements.—Flexion, extension, and lateral movements between the opposed bodies, and gliding and rotation between the articular processes.

Sacro-coccygeal Articulation.—This belongs to the class **amphiarthrosis.** The bony elements are the fifth sacral and first coccygeal vertebræ. The opposed surfaces are transversely oval, and are separated by an intervertebral disc, unless in advanced life, when ankylosis takes place, this occurrence being earlier and more frequent in the male than in the female. The ligaments are as follows: **anterior** and **posterior sacro-coccygeal,** which are continuations of the anterior and posterior common ligaments of the bodies of the vertebræ; **supracornual,** which pass between the sacral and coccygeal cornua; and **intertransverse** or **lateral,** which pass between the inferior lateral angles of the sacrum and the transverse processes of the first coccygeal vertebra. The latter ligament is liable to become ossified.

Arterial Supply.—Inferior lateral and middle sacral arteries.

Nerve-supply.—Lower two sacral, and coccygeal, nerves.

Movements.—Forward and backward movements are allowed.

Intercoccygeal Articulations.—These only exist prior to middle life. The union between the coccygeal segments is effected by intervertebral discs, and anterior and posterior ligaments. The adjacent fibres of the great and small sacro-sciatic ligaments serve as lateral ligaments.

Sacro-iliac Articulation.—This belongs to the class **amphiarthrosis.** The bony elements are the auricular and ligamentous surfaces of the sacrum and ilium. The cartilage of the auricular surface is about $\frac{1}{12}$ inch thick, and it may be a single plate for both surfaces,

or it may exist as two plates, one for each surface, in which latter case a small synovial cavity exists between the two plates. When the bones are forcibly separated, a portion of the cartilage is usually left adherent to each auricular surface. The ligaments at the joint are anterior, posterior, and oblique. The **anterior sacro-iliac ligament** is composed of short fibres which are placed in front of the joint. The **posterior sacro-iliac ligament,** which is very strong, extends from the ligamentous surface of the ilium to the ligamentous surface of the sacrum and the transverse tubercles on the dorsum of the bone, the direction of the fibres being downwards and inwards. The **oblique sacro-iliac ligament** lies superficial to the posterior, and extends from the posterior superior iliac spine and the adjacent part of the iliac crest to the third and fourth transverse tubercles on the dorsum of the sacrum. It is really a detached part of the posterior sacro-iliac ligament. The great and small sacro-sciatic ligaments are accessory to this joint.

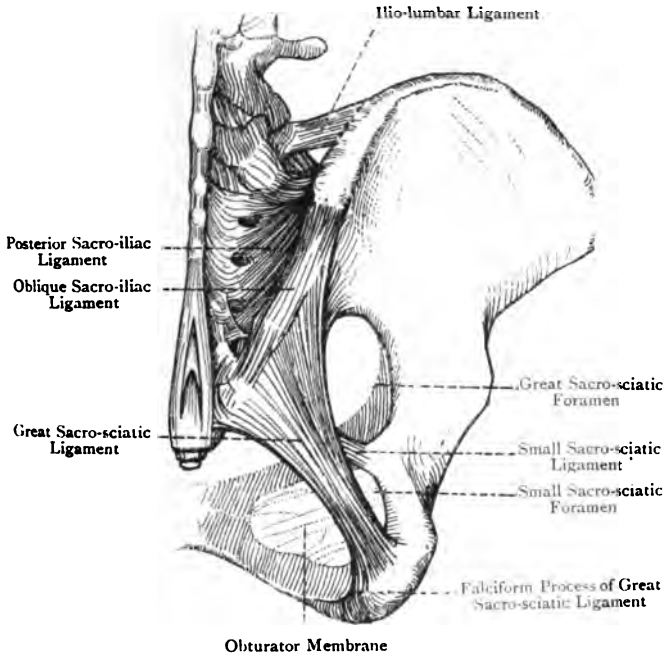


FIG. 364.—LIGAMENTS OF THE RIGHT HALF OF THE PELVIS (POSTERIOR VIEW).

The **great** or **posterior sacro-sciatic ligament** is attached by one extremity to the posterior inferior iliac spine, and the sides of the last three sacral and first coccygeal vertebræ, and by the other extremity to the inner border of the tuber ischii. From

this latter point it sends forwards an expansion, called the **falciform process,** which is attached to a sharp ridge on the lower part of the inner surface of the ramus of the ischium, close to its internal border. The ligament is broad at its attached ends, especially the upper, but in crossing towards the tuber ischii it becomes narrow. Its direction is downwards and forwards, and its ischial fibres are continuous with the tendinous origin of the long head of the biceps femoris. By its superficial surface it gives origin to part of the gluteus maximus, and resting on this surface are the plexiform loops formed by the external branches of the posterior primary divisions of the first three sacral nerves. Its deep surface gives origin to some fibres of the pyriformis, and lower down is intimately connected with the small sacro-sciatic ligament. The falciform process affords attachment to the lower part of the parietal pelvic fascia. The great sacro-sciatic ligament is pierced by the coccygeal branch of the sciatic artery, the sacral branch of the internal pudic artery, and the perforating cutaneous nerve from the sacral plexus. The ligament assists in the formation of the great and small sacro-sciatic foramina.

The great sacro-sciatic ligament is to be regarded as the separated tendon of the long head of the biceps femoris muscle.

The **small** or **anterior sacro-sciatic ligament,** which is triangular, is attached by its base to the sides of the last two sacral and first coccygeal vertebræ, where it is intimately connected with the more superficially placed great sacro-sciatic ligament. Its apex is attached to the tip of the spine of the ischium. Its deep surface is incorporated with the coccygeus muscle, and, along with the spine of the ischium, it forms the separation between the great and small sciatic foramina.

The small sacro-sciatic ligament is to be regarded as resulting from the fibrous degeneration of the superficial part of the coccygeus muscle.

Arterial Supply of the Sacro-iliac Articulation.—Ilio-lumbar, superior lateral sacral, and gluteal arteries.

Nerve-supply.—Superior gluteal, and anterior primary divisions, and external branches of the posterior primary divisions, of the first two sacral nerves.

Movements.—Stability being required at this joint, it is almost immovable. The two ossa innominata by their union at the pubic articulation form an arch, the convexity of which is directed downwards and forwards. The piers of this arch are separated by a wide interval, into which the sacrum fits in the form of a wedge. The sacrum being narrower behind than in front, the superincumbent weight of the trunk has a tendency to displace it downwards into the pelvic cavity, but this is resisted partly by the powerful posterior sacro-iliac ligaments, which suspend the bone, and partly by the strong hold which the sacrum has upon the ilium, in virtue of the irregularities of the opposed surfaces. Under the influence

of the superincumbent weight there is a tendency on the part of the sacrum to rotate round an axis passing transversely through the sacro-iliac joints. This tendency, however, is checked by the great and small sacro-sciatic ligaments. The ilio-lumbar ligaments prevent displacement of the fifth lumbar vertebra over the base of the sacrum.

Symphysis Pubis.—This belongs to the class **amphiarthrosis.** The articular surfaces are the symphysial aspects of the pubic bones. The ligaments are anterior, posterior, superior, inferior, and interpubic disc. The **anterior pubic ligament** is strong, and is composed of superficial and deep fibres. The superficial fibres are arranged in an obliquely decussating manner, and are chiefly constructed by the aponeurotic fibres of the external oblique and inner heads of the recti abdominis muscles. The deep fibres are disposed transversely. The **posterior** and **superior pubic ligaments** are weak, and consist of scattered fibres. The **inferior** or **subpubic ligament** is a strong, thick band of fibres, which lies at the antero-superior part of the subpubic arch, where it fills up and rounds off the subpubic angle. It is attached superiorly to the lower part of the interpubic disc, and laterally to the adjacent parts of the inner lips of the descending pubic rami. It is about ¼ inch in depth, and is slightly arched, from which latter circumstance it is known as the *ligamentum arcuatum.* The **interpubic disc** lies between the plates of cartilage which cover the bony articular surfaces. It is composed of fibro-cartilage, is thicker in front than behind, and usually contains a fissure at its upper and back part, which may extend for one half, or even the whole length, of the disc as an oblique cleft, parallel to the plane of the bony surfaces. This fissure is brought about by absorption of the tissues in that situation, and it does not appear until about the tenth year of life. It is larger in the female than in the male.

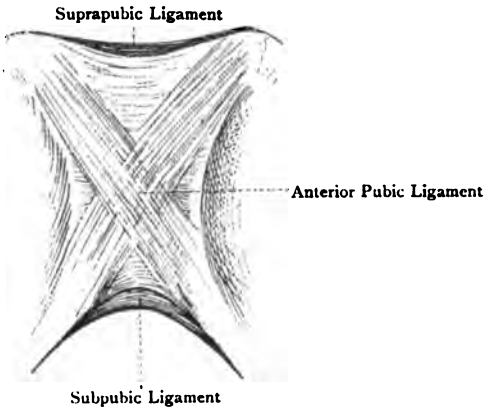


FIG. 365.—THE LIGAMENTS OF THE SYMPHYSIS PUBIS (ANTERIOR ASPECT).

The depth of the symphysis pubis is less in the female than in the male.

Arterial Supply.—Pubic branches of the deep epigastric and obturator, and superior or superficial external pudic arteries.

Nerve-supply.—Probably the hypogastric branch of the ilio-hypogastric, inguinal, and pudic nerves.

Movements.—Very slight separation is allowed at this joint, due to yielding of the connecting structures. This is most apparent during pregnancy and parturition.

FIG. 366.—VERTICAL SECTION OF THE SYMPHYSIS PUBIS.

Great Sacro-sciatic Foramen.—This foramen is formed by the great sciatic notch, the spine of the ischium, the great sacro-sciatic ligament, and the small sacro-sciatic ligament. For its compartments, and the structures which pass through them, see p. 404.

Small Sacro-sciatic Foramen.—This foramen is formed by the small sciatic notch, the spine of the ischium, the great sacro-sciatic ligament, and the small sacro-sciatic ligament. For the structures which pass through it, see p. 405.

Obturator Membrane and Obturator Canal.

The **obturator membrane,** also called the **thyroid membrane,** is attached to the circumference of the obturator foramen, except superiorly opposite the obturator groove, which it converts into a fibro-osseous canal for the passage of the obturator vessels and nerve. In this situation it is joined posteriorly by the parietal pelvic fascia. Its fibres are arranged in an irregular, decussating manner. Its posterior or pelvic surface is closely covered by the obturator internus muscle. The anterior or femoral surface is in like manner covered by the obturator externus muscle, and at its circumference there is an arterial loop, formed by the external and internal terminal branches of the obturator artery.

The **obturator canal** is a fibro-osseous canal, which is situated above the upper border of the obturator membrane. Its upper boundary, which represents the osseous element, is formed by the obturator groove on the inferior surface of the superior pubic ramus, the direction of the groove being downwards, forwards, and inwards. The lower boundary, which represents the fibrous element, is formed by the junction of the parietal pelvic fascia with the upper border of the obturator membrane over the upper border of the obturator internus. The canal transmits the obturator vessels and obturator nerve, the nerve being above the artery.

GUIDE TO THE DISSECTION OF THE ABDOMEN.

Male Perineum.

Before the subject is placed in the lithotomy positon the dissectors should practise passing the catheter, which should then be left in the urethra and bladder. The subject having been placed in the lithotomy position, the penis and scrotum are to be tied up to the end of the catheter. The first duty of the dissector is to make himself familiar with the landmarks, boundaries, and arbitrary divisions of the perineum, and he should have before him a ligamentous pelvis. He should also introduce his finger well into the rectum, when he will feel through its upper wall the following structures in order from without inwards: (1) the membranous part of the urethra, with the catheter lying in it; (2) the posterior or rectal surface of the prostate gland, easily recognised by its firmness and resistance; and (3) the external trigone of the bladder, which is destitute of peritoneum. The rectum is then to be lightly stuffed with tow, and the margins of the anal aperture are to be brought together with a few stitches. Before removing the skin the dissector should note the antero-posterior median raphé in the uro-genital division of the perineum, and he should follow this raphé over the posterior and anterior surfaces of the scrotum to the under surface of the penis. He should note the position of the central tendinous point, which is about an inch in front of the anus. He should also observe that the anus is situated posterior to a line connecting the front parts of the ischial tuberosities. A slight hollow on the surface between the anus and the tuber ischii indicates the situation of the ischio-rectal fossa.

To remove the skin the following incisions should be made: a median incision, extending from the root of the scrotum to the tip of the coccyx, and surrounding the anus; a transverse incision, extending outwards from the tip of the coccyx for fully 3 inches; another transverse incision, extending outwards from the central tendinous point for fully 3 inches; and a third transverse incision, extending outwards from the anterior extremity of the median incision (at the root of the scrotum) for a similar distance. The sphincter ani externus is to be first displayed. An effort should be made to show the corrugator cutis ani, but this is not an easy dissection. Between the tip of the coccyx and the anus the dissector will meet with the hemorrhoidal or perineal branch of the fourth sacral nerve, and, in the region of the anus and over the ischio-rectal fossa, will be found twigs of the inferior hemorrhoidal nerve. The lower border of the gluteus maximus is next to be dissected, taking care to preserve the gluteal cutaneous branches of the small sciatic nerve and sciatic artery, and the perforating cutaneous branch of the sacral plexus, the latter making its appearance near the coccyx. The dissectors should conjointly make an effort to show the ano-coccygeal body, which lies in the middle line between the tip of the coccyx and the anal canal.

The fat is to be removed from the ischio-rectal fossa, in doing which its loose character is to be noted, as well as the fact that it fills up the fossa, and also extends into the anterior and posterior diverticula connected with it. In removing the fat the dissector should cut from the anus outwards, taking care to preserve the inferior hemorrhoidal vessels and nerve, which cross the fossa transversely. In removing the fat from the front part of the fossa the superficial perineal artery and the two superficial perineal nerves, external and internal, are to be preserved. The outer wall of the fossa is to be dissected, showing the obturator fascia covering the obturator internus muscle, and containing Alcock's canal. Upon one side Alcock's canal should be opened and its contents displayed, in the following order from below upwards: the perineal division of the pudic nerve, vena comes, internal pudic artery, vena comes, and dorsal nerve of the penis. The position of the artery, its distance from the surface, and its relation to the tuber ischii are to be noted. An opening is also to be made in the obturator fascia to

show the fibres of the obturator internus muscle. In dissecting the inner wall of the fossa the anal or ischio-rectal fascia is to be studied, and thereafter removed to show the levator ani muscle descending upon the side of the rectum and anal canal. Posterior to the levator ani is the coccygeus, and emerging between the two will be found the hemorrhoidal or perineal branch of the fourth sacral nerve. Under cover of the lower border of the gluteus maximus there should be shown the inferior border of the great sacro-sciatic ligament. The anterior limit of the fossa is not to be disturbed in the meantime, but the dissector should make himself aware that it is partially limited by the reflection of Colles's fascia round the superficial transverse perineal muscle to join the base of the triangular ligament.

The ischio-rectal fossa having now been displayed, the following points in connection with it are to be noted : its measurements, including its depth; its boundaries, and, in connection with the outer boundary, the position of the internal pudic vessels, and in connection with the inner boundary, the rectum and anal canal ; the loose fat which fills the fossa ; the inferior hemorrhoidal vessels and nerve crossing the fossa from side to side ; and the superficial perineal artery and two superficial perineal nerves in the anterior part of the fossa, passing in a forward direction. It is further to be observed that there are two prolongations or diverticula connected with the fossa, anterior and posterior. The anterior diverticulum is to be found at the front part of the fossa above the junction of Colles's fascia with the base of the triangular ligament. It is of large size, and reaches almost as far forwards as the symphysis pubis, but it will be better understood in the deep dissection of the anterior part of the perineum. The posterior diverticulum will be found between the great sacro-sciatic ligament and the lower border of the gluteus maximus, its direction being outwards and inwards.

The dissector is now to turn his attention to the anterior or uro-genital division of the perineum. The arrangement of the superficial fascia is to receive careful attention. It can easily be shown to be divisible into a subcutaneous fatty layer, having no special name, and a deep membranous layer, known as the fascia of Colles. The subcutaneous fatty layer is traceable backwards over and into the ischio-rectal fossa, outwards to the inner aspect of the thigh, and forwards into the scrotum, where it will be again noticed. The fascia of Colles has an important bearing upon the course taken by urine when extravasated into the anterior part of the perineum. The disposition of this fascia is best studied by inserting the end of a blow-pipe underneath it at its back part, on one side of the middle line. Air having been blown in, the fascia will be seen to be attached externally to each ischio-pubic ramus ; posteriorly it turns round the posterior border of each superficial transverse perineal muscle to join the base of the triangular ligament ; internally (towards the median line) it is continuous with the corresponding fascia of the opposite side ; and anteriorly it passes into the scrotum, where it joins the subcutaneous fatty layer, and forms the tunica dartos. Inflation with air reveals the fact that beneath the fascia there is a space known as the perineal pouch, which is divided posteriorly into two compartments by an incomplete septum. This is demonstrated by the air at first passing forwards on its own side, then crossing the median line, and travelling backwards on the opposite side. Further, the air passes forwards into the scrotal wall beneath the dartos tunic. The attachments of the fascia of Colles clearly explain in what direction extravasated urine can only pass, and from what courses it is debarred.

Beneath Colles's fascia the following structures are to be dissected on each side, namely, the superficial perineal vessels and the three long scrotal nerves. The two superficial perineal nerves will be found entering the perineal pouch at its back part, and the long pudendal nerve of Soemmering will be found appearing through the fascia lata of the thigh about an inch in front of the tuber ischii, after which it passes inwards and forwards, entering the perineal pouch from the outer side. All these structures are to be dissected forwards to the scrotum. The following structures are next to be dissected : the bulbo-cavernosus, covering the bulb in the middle line ; the ischio-cavernosus,

covering the crus penis along the line of the ischio-pubic ramus; and the superficial transverse perineal muscle, in the direction of a line passing inwards and forwards from the tuber ischii to the central tendinous point. This last muscle is often very indistinct, and in its dissection care is to be taken to preserve the transverse perineal artery, which lies close to the muscle.

The dissector should now separate the ischio-cavernosus from the bulbo-cavernosus, and the deep perineal triangle will be thereby exposed. In the area of each triangle a membrane will be seen, which represents the antero-inferior layer of the triangular ligament of the urethra. Through it the fibres of the compressor urethræ muscle may be visible. At this stage the dissector should study the central tendinous point of the perineum, and note the various muscles which are connected with it. The bulbo-cavernosus muscle of one side is now to be carefully removed from the bulb of the urethra, by cutting along the median raphé between the two muscles. The different modes of insertion of the muscle are to be observed, and the bulb of the urethra is to be studied, its relation to the triangular ligament and central tendinous point being noted. The ischio-cavernosus should next be reflected, and attention given to the crus penis.

The dissector is now ready to study the triangular ligament of the urethra. Its antero-inferior layer, also called the subpubic fascia or deep perineal fascia, has been already laid bare in the area of each deep perineal triangle. The several structures piercing it are to be noted, and it should be observed that the base of this layer is joined by the fascia of Colles. This layer having been studied in all its bearings, attention should be directed to the subpubic ligament, which will be found close below the symphysis pubis. The antero-inferior layer of the triangular ligament is now to be carefully removed, and the following structures are to be dissected: the compressor urethræ, the posterior fibres of which are known as the transversus perinæi profundus; the internal pudic vessels and dorsal nerve of the penis, lying close to the ischio-pubic ramus; the following branches of the internal pudic artery, namely, the artery of the bulb or of the corpus spongiosum, lying usually about half an inch from the base of the triangular ligament, the artery of the crus or of the corpus cavernosum, and the dorsal artery of the penis; a plexus of veins lying in the compressor urethræ muscle, and receiving its tributaries from the corresponding corpus cavernosum, and one half of the corpus spongiosum and bulb; and Cowper's glands, two in number, situated one at either side of the middle line, underneath the membranous part of the urethra. The postero-superior or deep layer of the triangular ligament is next to be dissected. It is very ill-defined, and will be found about half an inch above and behind the antero-inferior layer. The structures which pierce it are to be noted, and the anterior diverticulum of the ischio-rectal fossa should now be studied, its floor being formed by the postero-superior layer. The membranous part of the urethra, with the catheter lying in it, is to be examined. The fibres of the postero-superior layer of the triangular ligament should be cut through in order to show the anterior fibres of the levator ani. The various structures which lie between the two layers of the triangular ligament are now to be carefully reviewed.

The dissector is next to direct his attention to the internal pudic artery and pudic nerve, making whatever dissection may now be necessary. The course, relations, and branches of these structures are to be studied. The structures which are divided in the operation of left lateral lithotomy are to be mastered, and, by way of concluding the dissection of the perineum, the dissector should cut transversely downwards at the central tendinous point so as to enable him to turn the anal canal and rectum well backwards. This will expose the rectal surface of the prostate gland.

Female Perineum.

The dissector should practise passing the female catheter before the subject is placed in the lithotomy position. When placed in position, he should make himself familiar with the landmarks of the perineum. Its three divisions are to be noted, and each constituent part of the pudendum

or vulva is to be carefully inspected. The guide already given to the dissection of the ischio-rectal or anal division of the male perineum is equally applicable to that of the female. An effort should be made to show the perineal body, which is peculiar to the female. The guide to it is the central tendinous point, of which it may be regarded as a deep expansion. In connection with the vaginal orifice the following structures are to be dissected: the bulbo-cavernosus or sphincter vaginæ; the bulbi vestibuli, one on either side of the orifice, and the pars intermedia of Kobelt, which is situated in front of the bulbi vestibuli; and the glands of Bartholin, which are also situated on either side of the vaginal orifice, just posterior to the bulbi vestibuli. If these glands should be displayed, an effort should be made to dissect their ducts, each of which is about three-quarters of an inch in length. The muscles requiring special attention are the following: the bulbo-cavernosus or sphincter vaginæ already dissected; and the ischio-cavernosus, or erector clitoridis. The other muscles are practically similar in both sexes. The internal pudic artery takes a similar course in the female to what it does in the male. The pudic nerve is practically the same in both sexes.

Antero-lateral Abdominal Wall.

The first duty of the dissector is to make himself familiar with the surface-markings of the anterior wall of the abdomen. The abdomen is to be inflated with air, by introducing a blow-pipe through the umbilicus. On withdrawing the blow-pipe, the opening is to be secured by a ligature, a circular cut through the skin, around and close to the umbilicus, having been previously made in order to give the string a hold. The skin is to be removed by making the following incisions: a median incision extending from the ensiform process of the sternum to the upper border of the symphysis pubis; an incision along the line of Poupart's ligament from the anterior superior iliac spine to the lower end of the median incision; a transverse incision from the ensiform process to a point as far outwards as the position of the body will allow; and another transverse incision from the anterior superior iliac spine inwards as far as the median line. The skin having been removed, the arrangement of the superficial fascia over the lower part of the anterior abdominal wall is to be studied. The region referred to extends from the level of Poupart's ligament upwards to the level of a line extending horizontally inwards from the anterior superior iliac spine to the linea alba.

A dissection of this region will show that the superficial fascia is divisible into a subcutaneous fatty layer, called Camper's fascia, and a deep membranous and elastic layer, known as Scarpa's fascia. This arrangement of the superficial fascia will at once recall to the dissector a similar arrangement of the superficial fascia of the anterior division of the perineum, the deep layer being there known as the fascia of Colles. A good guide to the separation between Camper's fascia and Scarpa's fascia is the superficial epigastric vessels (especially the vein), Camper's fascia being superficial to them and Scarpa's fascia underneath them. The difference in the naked-eye appearance of the two fasciæ is usually a sufficient indication of the existence of two layers, Camper's fascia being fatty, and Scarpa's fascia membranous. Along the line of the groin the separation is quite distinct, being here effected not only by the superficial epigastric vessels, but also by the inguinal glands (superior or oblique superficial inguinal glands). The dispositions of Camper's fascia and Scarpa's fascia are to be very carefully studied, especially the disposition of Scarpa's fascia, beneath which extravasated urine ultimately comes to lie in cases of rupture of the bulb of the urethra in the perineum. A careful incision is to be made through Camper's fascia transversely inwards from the anterior superior iliac spine. Before dividing it along the linea alba its continuity with the corresponding fascia of the opposite side is to be noted, and, in turning it downwards to the front of the thigh, this should be done in concert with the dissector of the lower limb. A similar transverse incision is next to be made through Scarpa's fascia as deep as the external oblique aponeurosis, and another vertical incision along the linea alba. The fascia

is then to be reflected downwards, partly by using the handle of the scalpel, and partly by using the fingers. Its connection with the external oblique aponeurosis is to be noted; its attachments along the line of the groin are to be demonstrated; and the manner in which this fascia, along with the fascia of Camper, is conducted by the spermatic cord into the scrotum to form the tunica dartos (or by the round ligament of the uterus into the labium majus), is to be studied. In the region of the symphysis pubis the suspensory ligament of the penis is to be dissected. The deep fascia is next to be examined. It will be found to be present over the lateral wall of the abdomen, where the external oblique muscle is fleshy, but, on being traced forwards, it will be seen to fade away, and ultimately to disappear, in the region of the aponeurosis of that muscle.

In the course of the foregoing dissection the superficial arteries, with their accompanying veins, are to be displayed, namely, the superior or superficial external pudic, crossing inwards and upwards over the spermatic cord (or round ligament of the uterus) to the suprapubic region; the superficial epigastric, turning upwards over Poupart's ligament a little to the inner side of the centre; the superficial circumflex iliac, lying below the outer part of Poupart's ligament; the anterior cutaneous arteries, emerging through the anterior wall of the sheath of the rectus abdominis, in a somewhat irregular manner, and at variable distances from the linea alba; and the lateral cutaneous arteries, appearing between the serrations of the external oblique in the mid-axillary line. Simultaneously with the dissection of the foregoing bloodvessels, the following cutaneous nerves should be dissected; the hypogastric branch of the ilio-hypogastric, piercing the external oblique aponeurosis about an inch above the external abdominal ring; the anterior cutaneous nerves, emerging through the anterior wall of the sheath of the rectus abdominis in a straggling manner, some appearing near the linea alba, and others a little farther from it; the lateral cutaneous nerves, which will be found emerging between the serrations of the external oblique in the mid-axillary line, and each of which (with one exception, which immediately follows) divides into an anterior and a posterior branch; the undivided lateral cutaneous or iliac branch of the anterior primary division of the twelfth thoracic nerve, which should be shown descending over the iliac crest, about an inch behind the anterior superior iliac spine, to the anterior part of the gluteal region; and the iliac branch of the ilio-hypogastric, descending to the gluteal region over the iliac crest at the junction of the middle and anterior thirds.

The superficial dissection of the penis and the dissection of the scrotum are next to receive attention. The prepuce and frenum præputii are to be examined, and the glans penis is to be studied, attention being paid to the meatus urinarius, corona glandis, and cervix. The median raphé of the scrotum is to be noted, and it may be traceable along the under surface of the penis. A catheter is then to be introduced into the bladder, and the penis is to be made tense by fixing it with string to the end of the instrument. The thin skin of the penis is to be carefully removed, and the reddish-coloured underlying fascia, continuous with the tunica dartos of the scrotum, is to be noted. If not previously dissected, the suspensory ligament is to be displayed, and its bilaminar disposition is to be shown. The fascial investment or sheath of the penis is to be studied, and thereafter the following structures are to be dissected: the dorsal vein, occupying a median position between the corpora cavernosa; the two dorsal arteries, one on either side of the vein; the dorsal nerves, each external to the corresponding artery; and the dorsal penile branches of the superior or superficial external pudic arteries, each lying external to the corresponding main dorsal artery. The dissection of the penis as regards structure is to be postponed until the pelvic cavity is dissected. The scrotum is now to be attended to. Having observed the dark colour and puckered condition of the skin, to the lateral aspect of which twigs of the inguinal nerve are distributed, the dissector is to remove it carefully, and thereafter study the brick-red scrotal fascia, known as the tunica dartos. The relation of the

dartos tunic to Camper's and Scarpa's fasciæ of the anterior abdominal wall, and to the two layers of the superficial fascia of the anterior division of the perineum, is to be carefully noted. The testis is next to be withdrawn from the scrotum, by making forcible traction upon the spermatic cord, and, when this has been done upon both sides, a view will be obtained of the interior of the scrotum. The dissector will notice that there are two scrotal chambers, each lodging a testis, and separated from one another by a partition, known as the septum scroti. The constituent parts of the scrotal wall and scrotal septum are next to receive attention, and the blood-supply and nerve-supply are to be fully reviewed.

The dissector should now replace the testis in the scrotum, and return to the dissection of the antero-lateral wall of the abdomen. The external oblique is to be dissected and studied. In dissecting the posterior border of the muscle its relation to the latissimus dorsi is to be noted. If it is not overlapped by the last-named muscle, the interval between them, called the triangle of Petit, is to be examined. The interdigitations with the latissimus dorsi and serratus magnus are to be shown, and, in connection with the external oblique aponeurosis, the intercolumnar fibres are to be displayed. In the region of the external abdominal ring these fibres are to be shown folding themselves around the spermatic cord in the form of the finger of a glove, thus forming the intercolumnar or external spermatic fascia. The attachment of this fascia along the pubic crest is to be noted, and, partly on this account, and partly by reason of the attachment of the intercolumnar fibres to the pillars of the external abdominal ring, it will be evident that extravasated urine, in passing upwards along the spermatic cord, cannot enter the inguinal canal. The following parts of the external oblique aponeurosis require special attention: Poupart's ligament; Gimbernat's ligament; the triangular fascia or ligament of Colles, which will be found lying within the external abdominal ring behind the spermatic cord and internal pillar; the external abdominal ring; and the linea alba. In connection with the external abdominal ring, its condition is to be carefully studied (1) in its natural state, (2) after partial dissection, a circular cut having been made in the intercolumnar fascia at the mouth of the ring, and (3) after complete dissection, the intercolumnar fibres having been completely removed. The following structures should be observed through the ring, namely, the triangular fascia or ligament of Colles, and the conjoined tendon of the internal oblique and transversalis abdominis. The position of the spermatic cord as it passes through the ring is to be noted.

The removal of the external oblique is to be effected in the following manner: an incision is to be carried inwards through the aponeurosis from the anterior superior iliac spine to the linea alba, and another is to be made vertically downwards in the median line to the symphysis pubis. The triangular flap of the aponeurosis so included, containing the external ring, is to be turned downwards, and left intact, so that it can be replaced when studying the inguinal region in connection with hernia. Beneath this portion of the aponeurosis the dissector is to preserve the hypogastric branch of the ilio-hypogastric nerve as far outwards as about an inch in front of the anterior superior iliac spine. The external oblique is next to be detached from the iliac crest and lower eight ribs, preserving the lateral cutaneous nerves, and the muscle, with the remainder of its aponeurosis, is to be reflected as far forwards as possible. At no point is it possible to reflect it quite up to the linea alba, but it can be reflected more completely below the level of the umbilicus than above it. The reason why the external oblique aponeurosis cannot be separately raised quite up to the linea alba will be seen to be because it blends inseparably with the subjacent anterior lamina of the aponeurosis of the internal oblique. This latter muscle is now to be cleaned, preserving the hypogastric branch of the ilio-hypogastric nerve, and the lateral cutaneous nerves, all of which pierce it. In cleaning the Poupart fibres of the muscle, the origin of the cremaster is to be brought into view. The complex relation of the Poupart fibres to the spermatic cord is to receive attention, and the cremaster is to be dissected. In connection with this muscle the genital

branch of the genito-crural nerve and the cremasteric branch of the deep epigastric artery are to be noted, and the cremasteric fascia is to be studied.

The internal oblique is to be removed in the following manner: make an incision carefully through the muscle just in front of the anterior superior iliac spine, and expose the lateral or intermuscular epigastric branch (so-called ascending branch) of the deep circumflex iliac artery. This is the best guide to the separation between the internal oblique and transversalis abdominis. Now carry an incision inwards through the internal oblique towards the linea alba, and leave the Poupart fibres undisturbed in the meantime. The internal oblique is next to be detached from the iliac crest, from the posterior aponeurosis of the transversalis abdominis, and from the lower three or four costal cartilages, and the muscle, with its aponeurosis, is to be thrown forwards as far only as the outer border of the rectus abdominis. During the reflection of the muscle care must be taken to preserve the following structures, namely, the lower five intercostal nerves; the anterior primary division of the twelfth thoracic nerve (subcostal nerve); the hypogastric branch of the ilio-hypogastric nerve; the inguinal (so-called ilio-inguinal) nerve; the lateral or intermuscular epigastric artery; the abdominal branches of the lumbar arteries; and the lower two intercostal arteries. The transversalis abdominis is next to be cleaned and studied. The lower five intercostal nerves and the anterior primary division of the twelfth thoracic nerve are to be followed forwards as far as the outer border of the rectus abdominis, where they disappear by piercing the sheath to get behind the muscle. The posterior aponeurosis of the muscle (which forms the lumbar aponeurosis) cannot be displayed in the present position of the body, but the anterior aponeurosis should be dissected as far as the outer border of the rectus abdominis, where it will be further studied in connection with the sheath of that muscle.

The dissector should now direct his attention to the Poupart fibres of the internal oblique and transversalis abdominis. He will find that the Poupart fibres of the two muscles are intimately connected together, but a careful dissection will show that, whilst the internal oblique arises from the outer half of Poupart's ligament on its abdominal aspect, the transversalis abdominis arises only from the outer third. The former muscle, then, reaches lower down along Poupart's ligament than the latter. An incision having been made through the transversalis abdominis in a transverse direction inwards from the anterior superior iliac spine, the Poupart fibres of the two muscles are to be detached from the ligament, and, in the course of reflecting them inwards without injuring the fascia transversalis, the dissector should observe their varying relations to the spermatic cord and internal abdominal ring, and also the lower border of each muscle. These fibres of the two muscles will be found to end in the conjoined tendon, and this structure should be followed to its insertion and studied. It will be found that the anterior aponeurosis of the transversalis abdominis contributes more to the conjoined tendon than the aponeurosis of the internal oblique. The relation of the conjoined tendon to Hesselbach's triangle will be presently seen. Meanwhile the dissector is to observe that the tendon lies behind the spermatic cord (or round ligament of the uterus), and that it also lies behind the external abdominal ring, thereby strengthening an otherwise weak part of the abdominal wall. The dissector should look for the reflected tendon of Cooper. If present, it will be found as a thin semilunar expansion, extending outwards from the outer border of the conjoined tendon to the inner and lower part of the internal abdominal ring, where it is attached to the deep crural arch. Its relation to Hesselbach's triangle, as well as to the inguinal canal, will be seen further on in the dissection. At this stage the dissector of the abdomen should associate himself with the dissector of the lower limb in order to make a dissection of the deep crural arch.

The anterior wall of the sheath of the rectus abdominis is now to be opened and reflected by making a vertical incision through it about an inch and a half from the linea alba, and turning one half inwards and the other outwards, preserving at the same time the transmitted nerves. In doing so the close

connection between the anterior wall of the sheath and the tendinous inscriptions of the muscle is to be noted at the following levels, namely, at the umbilicus, opposite the tip of the ensiform process, and about midway between these two points. Occasionally a fourth connection is established a little below the umbilicus. The anterior wall of the sheath having been reflected, the pyramidalis muscle should be dissected. If present, it will be found in front of the lower part of the rectus abdominis. The rectus itself is then to be fully dissected. Its two heads of origin and three slips of insertion are to be shown, and the three (sometimes four) tendinous inscriptions are to be studied. The varying relation of the inner border of the muscle to its fellow along the linea alba is to be observed, and both borders of the muscle are to be freed from their connections. In freeing the outer border, the lower five intercostal nerves and the anterior primary division of the twelfth thoracic nerve are to be shown on their way to the back of the muscle (within the sheath). The deep epigastric artery is to be displayed, disappearing beneath the outer border of the muscle at a point about midway between the upper border of the symphysis pubis and the umbilicus. Before further disturbing the muscle, the triangle of Hesselbach is to be studied. It will be found between the lower fourth of the rectus abdominis and the deep epigastric vessels. The relation of the conjoined tendon to the triangle, and the manner in which it divides the triangle into two compartments are to be noted. If the reflected tendon of Cooper should be present, its relation to the triangle is also to be noted.

The rectus abdominis is now to be raised from its sheath, but not yet divided. As this is being done, the lower five intercostal nerves and the anterior primary division of the twelfth thoracic nerve will be seen making their way from behind forwards through the muscle to become anterior cutaneous nerves. At this stage also the superior epigastric artery is to be shown entering the deep surface of the upper part of the muscle from behind the seventh costal cartilage. The continuation of the deep epigastric artery in the substance of the muscle is to be dissected from behind to a point about 2 inches above the umbilicus, and the anastomosis between it and the superior epigastric at that level may be shown. The sheath of the rectus is next to be studied, the muscle itself having been previously divided a little above the umbilicus. The splitting of the internal oblique aponeurosis into two laminæ anterior and posterior, along the outer border of the muscle is to be shown. This, however, will be found to cease at a point a little above the level of the anterior superior iliac spine, below which point the undivided aponeurosis will be found to pass in front of the muscle. The anterior aponeurosis of the transversalis abdominis will be seen to pass behind the rectus for a similar extent to that over which the splitting of the internal oblique aponeurosis takes place ; but, over the lower part of the muscle (below a point a little above the level of the anterior superior iliac spine), it passes in front of it. The deficiency of the sheath posteriorly over its lower fourth is to be noted, and the semilunar fold of Douglas, with the deep epigastric artery passing over it, is to be studied. Sometimes the anterior aponeurosis of the transversalis abdominis will be found to send scattered fibres behind the rectus for a variable distance below the semilunar fold of Douglas. In such cases another curved semilunar fold, known as the band of Henle, is to be looked for from 1 to 2 inches below the semilunar fold of Douglas. The composition of the sheath in front and behind is to be mastered ; the different attachments superiorly of the anterior and posterior walls are to be noted ; the contents of the sheath are to be studied ; and the linea alba should be thoroughly revised. The dissector should next direct attention to that part of the deep epigastric artery which forms the outer boundary of Hesselbach's triangle, showing its relations to the internal abdominal ring and fascia transversalis, and also its two venæ comites. The cremasteric and pubic branches of the artery are to be shown, but the artery itself is not to be followed, at this stage, to its origin from the external iliac. The deep epigastric artery should now be studied throughout its course, its branches should be mastered, and the anastomoses of the vessel should be carefully attended to.

The next stage of the dissection consists in (1) detaching the transversalis abdominis from the iliac crest, (2) cutting through posterior aponeurosis in the region between the iliac crest and the last rib, and (3) dividing the muscle as it escapes from beneath the costal margin. When the muscle has been reflected forwards to the outer border of the rectus, the various nerves on its surface having been divided in front and turned outwards, and the ilio-hypogastric and inguinal nerves being carefully preserved in the region of the iliac crest, a good view will be obtained of the fascia transversalis. Before proceeding to study this fascia, however, it will well repay the dissector to replace for a moment the external oblique, internal oblique, and transversalis abdominis, in order to show the intricate piece of lattice-work which these muscles construct by the varying direction of their fibres, a circumstance which adds materially to the strength of the abdominal wall. The fascia transversalis should be followed upwards beneath the costal margin, where, now very thin, it becomes continuous with the areolar investment of the diaphragm. Towards the lower part of the abdominal wall it becomes better marked. Its disposition along the linea alba and along the iliac crest is to be studied ; its arrangement along the line of Poupart's ligament should be carefully attended to ; the deep crural arch is to be revised in connection with it ; its relation to Hesselbach's triangle is to be noted ; and the internal abdominal ring, with the infundibuliform fascia prolonged from its margins, is to receive the closest attention. To see the ring the spermatic cord (or round ligament of the uterus) should be pulled upon, and a circular incision made through the infundibuliform fascia close to the ring. In performing this dissection, it will be seen that the infundibuliform fascia is prolonged upon the cord as the internal spermatic fascia. If the cord be pulled upon it will be seen to receive a covering from the subperitoneal fat or areolar tissue through the internal ring. The internal abdominal ring in all its bearings is to be fully studied, and the relation of the deep epigastric vessels to it carefully noted. At this stage the deep circumflex iliac artery should be dissected in the first part of its course. It will be found in a canal behind the outer half of Poupart's ligament formed by the meeting of the fascia transversalis and fascia iliaca, but it should not be dissected at this stage beyond the anterior superior iliac spine, in which region it will be found to pierce the fascia transversalis.

The inguinal canal is next to be attended to, and its boundaries and relations studied. The spermatic cord, or round ligament of the uterus, according to the sex, is to be observed traversing it throughout, and the inguinal nerve will be found in the lower two-thirds of the canal, after which it will be seen to emerge through the external abdominal ring external to the spermatic cord. Hesselbach's triangle should be revised at this stage, and the relation of the conjoined tendon to the inguinal canal is to be noted. Further, if the reflected tendon of Cooper should be present, its relation to the canal is to be observed. The spermatic cord is next to be dissected. Lying in front of its upper part for a variable distance may be found a thread-like prolongation of the peritoneum. The various coverings of the cord are to be studied, and the dissector is to note that there are three spermatic fasciæ. By teasing and separation the various constituents of the cord are to be shown. Certain of these will not be easily made out, such as the spermatic plexus of nerves and the lymphatics of the testis, but the vas deferens can be separated without difficulty. The spermatic artery (in the centre of the cord), the pampiniform plexus of veins, and the deferential artery are to be looked for. The round ligament of the uterus (a very variable structure in this part of its course) requires very little dissection, and may be followed into the labium majus. A few fibres, representing the cremaster muscle in the male, should be looked for in front of the round ligament. The fascia transversalis is now to be removed as carefully as possible, and in doing so the dissector should observe that it is connected to the underlying peritoneum by the subperitoneal fat or areolar tissue. In connection with this tissue two points have to be noted, namely, (1) internal to the external iliac vein it forms the septum crurale, closing the crural or femoral ring, which should be studied in conjunction with the

dissector of the lower limb; and (2) at the internal ring it is carried downwards with the spermatic cord.

The parietal peritoneum is now to be examined. It will be readily recognised by its bluish-white colour, and upon it a small nodule is to be looked for just behind the internal abdominal ring, representing the upper end of the original processus vaginalis. Instead of a mere nodule the dissector may find a fibrous thread descending for a variable distance on the spermatic cord, and sometimes containing a canal in the female, known as the canal of Nuck. The disposition of the fascia transversalis and fascia iliaca along the outer half of Poupart's ligament, and in the region of the external iliac vessels at the groin is to be attended to, the deep crural arch being at the same time revised. Gimbernat's ligament may be looked to at this stage, but its complete examination should be postponed till a later period.

The abdominal cavity is now to be opened. This is to be done only partially at first by means of the following incisions: commencing immediately below the umbilicus, an incision is to be made downwards and outwards, on either side, to Poupart's ligament at the junction of its inner two-thirds and outer third. In this manner a triangular portion of the anterior abdominal wall below the umbilicus can be thrown down. The parietal peritoneum lining this portion having been sponged, the following plicæ and fossæ are to be studied: (1) Folds.—(*a*) plica urachi, in the middle line; (*b*) plica hypogastrica; and (*c*) plica epigastrica, which is usually a little external to the plica hypogastrica, though sometimes the two correspond. (2) Fossæ.—These are the internal, middle, and external inguinal fossæ. The relations of the internal and middle fossæ to the two divisions of Hesselbach's triangle are to be noted, as well as the relation of the external fossa to the internal abdominal ring. At this stage the dissector should study the descent of the testis, and the abnormal conditions of the processus vaginalis. A complete revisal of all the structures of the abdominal wall in the region of Poupart's ligament should now be made, and thereafter inguinal hernia is to receive careful attention in the following order: external oblique hernia; internal direct hernia; internal oblique hernia; congenital hernia; and infantile hernia. Having mastered these varieties of hernia, the dissector should now turn his attention to umbilical hernia, or exomphalos. The relation of structures at the pubic crest is next to be mastered, as well as the relation of parts at the pectineal portion of the ilio-pectineal line.

It will be proper to dissect the testis at this stage, if it is in proper condition. If not, it should be delayed until the organ has been sufficiently hardened by immersion in spirit. The testis, along with the lower part of the spermatic cord, is to be removed and laid upon a board, and the parts are to be kept in position by pins. The tunica vaginalis is to be studied, and the dissector should note that the lower fibres of the cremaster spread out in a scattered manner over its upper part. An attempt should be made to inflate it, by making an aperture in it, just large enough to admit the small end of a blow-pipe. If this is successfully done, an instructive view of the membrane will be obtained. The tunica vaginalis is then to be divided by a vertical incision, when its two parts will come readily into view, namely, tunica vaginalis scroti and tunica vaginalis testis. These two parts having been studied, attention is next to be directed to the following structures: (1) the body of the testis, closely invested by the dense tunica albuginea, which, in turn, is closely covered by the tunica vaginalis testis; (2) the epididymis, which will be seen lying along the posterior border and adjacent portion of the external surface of the testis; and (3) the digital fossa, which is a recess formed by the tunica vaginalis testis between the testis and the epididymis. The epididymis will be seen to be composed of a head or globus major, situated at the upper end; a body, succeeding to the head, long and narrow; and a tail or globus minor, situated at the lower end of the body. Before proceeding further, the dissector should look carefully for the following vestiges of embryonic structures, namely (1) the hydatids of Morgagni, which will usually be seen on the front of the globus major, or on the front of the testis just below the globus major; (2) the organ of Giraldés or para-

didymis, situated on the front of the spermatic cord immediately above the globus major, beneath the visceral layer of the funicular portion of the tunica vaginalis; and (3) the vas aberrans of Haller, situated at the point where the globus minor passes into the vas deferens. The tissue between the globus major and the testis should be carefully unravelled, and an effort made to show the coni vasculosi entering the globus major after leaving the testis. The vas deferens should be shown as it passes off from the globus minor, and the tortuosity which it here presents is to be noted. The tunica albuginea is next to be opened by making a vertical, median, anterior incision. On separating the two halves from the substance of the testis the dissector is to observe the fibrous processes, thereby torn, which pass into the interior of the organ between the lobuli testis. An attempt should now be made to show the lobuli testis by teasing out the glandular tissue, which may bring into view the tubuli seminiferi. A transverse incision should next be made through the testis, in order to show the forward projection of the tunica albuginea from the back part of the testis into the interior for a short distance, known as the corpus Highmorianum, or mediastinum testis.

The abdominal wall above the umbilicus is to be removed by making a vertical incision through it at either side of the middle line, thus preserving meanwhile a median strip. The lateral parts of the wall are then to be divided along each costal margin as far back as the position of the body will allow. Reverting to the median vertical strip, the dissector should study on its posterior surface a median fold of parietal peritoneum, representing a part of the falciform ligament of the liver, which contains the obliterated umbilical vein. The umbilicus and this peritoneal fold are to be preserved.

Without in any way disturbing the contents of the abdominal cavity, the dissector should remove with a sponge any fluid which may have accumulated. He should then make himself acquainted with the various regions into which the cavity is divided, and the lines and planes by which these divisions are effected. He should also study the boundaries of the cavity. The succeeding stages of the dissection being very complicated, it is advisable that the dissector should exercise considerable method in his mode of procedure. His first duty is to take a *superficial* view of the contents of the abdomen in their undisturbed position, and this should be done in the following order: the liver, the stomach, and the great omentum, depending from the great curvature of the stomach. It should be noted that the great omentum descends lower on the *left* side than on the right, and that a few coils of the ileum are visible beyond it on the right side. The cæcum will be partly seen in the right iliac fossa, and the iliac colon is partly visible in the left iliac fossa.

The great omentum is next to be raised and laid over the costal margin, when the coils of the jejunum and ileum will come into view. The transverse colon will also be seen crossing from the right to the left hypochondrium. If the urinary bladder should be distended, a part of it would be seen in the hypogastrium. The foregoing represent the contents which are seen on taking a superficial view. The coils of the jejunum and ileum should now be carried over to the left side, and the ascending colon examined. Superiorly it will lead to the hepatic flexure, and, without disturbing the parts, the right kidney should be felt. The cæcum will now be fully exposed at the lower end of the ascending colon, and the vermiform appendix, and the mode of ending of the ileum in the large intestine, should be carefully examined. The coils of the jejunum and ileum are then to be carried over to the right side, and the descending colon, commencing above at the splenic flexure and terminating below in the iliac colon, is to be examined. The left kidney is to be felt for, and, if the jejunum is followed upwards, the duodeno-jejunal flexure will be exposed.

The dissector should now study (1) the position and connections of the stomach, and (2) the position and connections of the intestinal canal (except the duodenum, pelvic colon, and rectum). In connection with the small intestine the possible presence of Meckel's diverticulum, about 3 feet from the ileo-cæcal valve, is to be borne in mind. In studying the large intestine,

special attention should be paid to the cæcum, including its varieties, and the vermiform appendix. The ascending, transverse, descending, and iliac colon should next be studied in the order named. The position and connections of the spleen are next to be studied, and for this purpose the stomach is to be well drawn out from the left hypochondrium. It is to be remembered that occasionally accessory spleens are met with in the gastro-splenic omentum, or in the great omentum. The dissector is next to turn his attention to the position, connections, ligaments, and component parts of the liver, in so far as they can at present be made out. The gall-bladder is to be included in this examination.

A study of the foregoing structures will have prepared the dissector for the examination of the peritoneum. The description given of this membrane and its various folds should be read, and it should be compared with, and verified from, the dissection. In a great number of bodies, however, verification is rendered impossible by the existence of adhesions, but the dissector should do his best. The continuity between the parietal and visceral peritoneum is to be shown in two ways, namely, in the vertical direction, and in the transverse direction. The continuity can be demonstrated in the vertical direction without much difficulty, and the best starting-point is the portal fissure of the liver. The peritoneum is to be traced in the transverse direction at two levels, namely, above the transverse colon, or at the level of the foramen of Winslow, and below the transverse colon, or at the level of the umbilicus. The former is difficult of accomplishment, but the dissector should try his best. The latter will not cause much trouble. The various folds formed by the peritoneum, namely, omenta, mesenteries, and ligaments, are next to be studied in the following order: (1) the great omentum; (2) the small omentum; (3) the gastro-splenic omentum; (4) the mesentery proper; (5) the appendicular mesentery or meso-appendix; (6) the transverse meso-colon; (7) the pelvic meso-colon (which, however, belongs to the pelvis); (8) the peritoneal ligaments of th · liver; (9) the peritoneal ligament of the stomach, namely, the gastro-phrenic ligament; (10) the peritoneal ligaments of the spleen, namely, the lieno-phrenic and lieno-renal ligaments; and (11) the peritoneal ligament of the splenic flexure of the colon, namely, the phreno-colic or costo-colic ligament (sustentaculum lienis). In connection with the ascending colon, a peritoneal fold, known as the sustentaculum hepatis, may be met with.

The cavity of the peritoneum is next to be studied, attention being given first to the great cavity, and then to the small cavity. The boundaries of the small cavity are to be studied, which will be facilitated by making an incision through the descending layers of the great omentum about an inch below the great curvature of the stomach. The hand should then be introduced through the incision into the small cavity, and, unless there are adhesions, the dissector will be able to insinuate it downwards between the descending and ascending layers of the great omentum until it is arrested where that omentum describes its bend. In this way the bag or sac of the omentum (great) is demonstrated. He should also pass his hand upwards behind the stomach and gastro-hepatic omentum, and he will feel Spigel's lobe of the liver at the upper end of the small cavity. Thereafter the foramen of Winslow should be mastered. It will be found behind the right or free border of the gastro-hepatic omentum. In order to familiarize himself with this opening, the dissector should again pass his hand into the small cavity through the incision already made below the stomach, keeping the thumb outside in the general cavity. If the hand (except the thumb) is now carried upwards behind the stomach and gastro-hepatic omentum, the index finger can easily be pushed through the foramen of Winslow (unless it is blocked by inflammatory products) into the great cavity, where it can be made to meet the thumb. Again, the index finger of one hand should be passed through the foramen into the small cavity, and the thumb of the same hand should be brought down upon the right or free border of the gastro-hepatic omentum. This having been done, the dissector will have two layers of peritoneum between the index finger and thumb, one of which belongs to the small cavity, and the other

to the great cavity. The structures contained between these two layers are to be noted. As the finger lies in the foramen of Winslow the caudate lobe of the liver will be felt above it. It is possible for a hernia to occur through this foramen.

The relation of the duodenum to the peritoneum should next be attended to. Certain peritoneal fossæ are to be studied in the following order: (1) the duodenal and duodeno-jejunal fossæ; (2) the peri-cæcal fossæ, namely, ileo-colic, ileo-cæcal, and retro-cæcal; and (3) the intersigmoid. The study of the peritoneum in the adult having been concluded, the dissector should attend to the condition of the peritoneum in the fœtus.

The dissection of the mesentery proper should now be proceeded with. The great omentum, with the transverse colon, is to be raised and laid over the costal margin, and the jejunum and ileum are to be carried over to the left side. The dissector is to place portions of the mesentery successively upon a platter, and remove the right or upper layer. The trunk of the superior mesenteric artery is to be dissected beyond the point where it escapes from under cover of the pancreas, and the superior mesenteric sympathetic plexus around it is to be noted, as well as the superior mesenteric vein on its right side. About twelve rami intestini tenuis are to be shown arising from the left side of the parent trunk, and these are to be followed out to their primary, secondary, and at least tertiary arches, attention being given at the same time to the accompanying sympathetic plexuses and veins. During this dissection the mesenteric glands are to be shown, and an effort should be made to display the lacteals, which enter the glands as afferent vessels, and emerge from them as efferent vessels.

The right side of the superior mesenteric artery will be found to give off, in order from above downwards, the inferior pancreatico-duodenal, middle colic, right colic, and ileo-colic branches, but they should be followed out from below upwards. The ileo-colic is to be shown dividing into a colic and an ileo-cæcal branch, the latter of which will be found to give off appendicular, anterior cæcal, posterior cæcal, and ileal branches. The right colic and middle colic are to be shown, each dividing into two branches, the latter lying between the two layers of the transverse meso-colon. Throughout this dissection the tributaries of the superior mesenteric vein are to be noted, as well as the offshoots from the superior mesenteric sympathetic plexus. The inferior pancreatico-duodenal artery should not be followed out at this stage.

The jejunum and ileum are now to be carried over to the right side, and the left branch of the middle colic artery is to be followed to its termination. This will guide the dissector to the descending branch of the left colic artery, and, as he follows this down, he will readily expose the trunk of the inferior mesenteric artery, arising from the aorta about 1½ inches above the bifurcation. In doing so, he is to note that the artery is behind the parietal peritoneum. It will be found to give off a left colic branch, one, two, or three sigmoid branches, and a superior hemorrhoidal branch. The inferior mesenteric sympathetic plexus and ganglion, and the offshoots from the plexus should be noted. The left colic and superior sigmoid arteries are to be followed to their distribution, and the superior hemorrhoidal is to be shown crossing the left common iliac vessels on its way to the pelvis, where it disappears between the two layers of the pelvic meso-colon. The superior hemorrhoidal, sigmoid, and left colic veins will be found to form the inferior mesenteric vein, which is to be followed upwards on the left psoas magnus as high as the pancreas, care being taken to show that it crosses the left spermatic artery and left renal vein.

The intestines are now to be removed in the following manner: a double ligature is to be placed upon the jejunum at its commencement, and another double ligature at the point where the iliac colon passes into the pelvic colon. The gut is then to be divided between each of these double ligatures, and the jejunum and ileum are to be separated from the mesentery proper by dividing the latter with a knife, or clipping it with scissors. When this has been done, the large intestine should be forcibly drawn out from its deep position, any adhesions which it has formed being severed with a knife. The parts of intestine left behind are (1) the duodenum, and (2) the pelvic colon and rectum.

The portion of gut removed is to be cleansed by allowing water to flow through it, and small portions are to be separated, inflated, and dried for future inspection. These portions are to be taken from the following regions: (1) the upper and lower ends of the jejunum; (2) the upper end, and near the lower end, of the ileum; and (3) two pieces from the ascending colon. One of these pieces, from the small intestine, is to be dissected in the inflated and moist condition, in order to show the longitudinal and circular muscular fibres. One of the pieces from the ascending colon, when inflated, should also be dissected in the moist condition.

The sacculated appearance and the three muscular tæniæ having been noted, the peritoneum is to be carefully removed, and the arrangement of the muscular fibres studied. Thereafter the three tæniæ are to be divided, and the elongation which then takes place in the wall of the gut is to be observed.

The small intestine is to be opened along the mesenteric border by means of a pair of scissors, one of the points of which has been guarded with a piece of cork. The gut is then to be spread out upon a board, and the characters of the mucous membrane are to be studied. A small portion should be examined under water with the aid of an ordinary lens, which will make clear the villi. With the exception of the cæcum and the first 2 inches of the ascending colon, the large intestine is to be treated in a similar manner. The cæcum and 2 inches of the ascending colon, along with the last 2 inches of the ileum, are to be treated in a different manner. The bowel is to be filled with water from the colic end, the ileal end being left free. It will then be seen that, in distension of the cæcum, no water escapes into the ileum, thus demonstrating the action of the ileo-cæcal valve. The exact attachment of the base of the vermiform appendix should be noted, and the meso-appendix should receive attention. The cæcum and colon are then to be laid open along the right wall, or that opposite the ileum, and the ileo-cæcal valve is to be studied. The opening of the vermiform appendix should be examined, and the valve of Gerlach, guarding it, noted. The extent to which the appendix is pervious should also be attended to.

It is advisable that the dissectors should associate themselves with the dissectors of another abdomen, in order that the cæcum and parts of the ascending colon and ileum from one abdomen may be inflated and dried, so as to allow of the ileo-cæcal valve being examined in the dried state.

The intestines having been studied, the dissector is to cut away the remainder of the mesentery proper, leaving only small portions of the superior mesenteric vessels, as well as of the inferior mesenteric vein, for future reference. A blow-pipe having been introduced into the small portion of the jejunum which has been left, the duodenum and stomach are to be moderately inflated, and the stomach is to be turned upwards. When this has been done, the position and connections of the duodenum are to be studied, the musculus suspensorius duodeni is to be shown passing between the duodeno-jejunal flexure and the left crus of the diaphragm, and the peritoneal fossæ in this region are to be revised. The position and connections of the pancreas are next to receive attention, followed by the spleen and the liver.

The blood-supply of the foregoing viscera should be shown by displaying the cœliac axis without injuring the important plexus of nerves which surrounds it. The axis will be found appearing at the superior border of the pancreas, where it breaks up into gastric, splenic, and hepatic branches, which are to be followed out in the order named. The gastric artery will be seen to pass upwards and to the left behind the small cavity of the peritoneum, and it is to be followed out. The splenic artery is recognised by taking a tortuous course to the left along the superior border of the pancreas, and its pancreatic, left gastro-epiploic, vasa brevia, and proper splenic branches are all to be shown. The hepatic artery is next to be dissected as far as the portal fissure of the liver. In displaying the vessel in front of the foramen of Winslow, opportunity is to be taken to show the common bile-duct descending on its right side, and the vena portæ ascending behind the two. The following branches are to be shown arising from the hepatic artery, all of which are to be followed out: (1) pyloric; (2) gastro-duodenal, dividing into superior

pancreatico-duodenal and right gastro-epiploic; and (3) right and left hepatic. The right hepatic branch will be found to give off the cystic artery, which divides into superior and inferior branches. It is at this stage that the inferior pancreatico-duodenal artery is to be studied.

In dissecting the foregoing arteries, the following groups of lymphatic glands are to be noted: (1) the cœliac glands surrounding the cœliac axis; (2) the gastric glands arranged in two sets—superior, along the small curvature of the stomach, and inferior, along the great curvature; (3) the pancreatic glands along the superior border of the pancreas; (4) the splenic glands near the hilum of the spleen; and (5) the hepatic glands within the gastro-hepatic omentum. The veins corresponding to the arteries are to be preserved, if possible, in connection with the portal system.

The vena portæ is to receive careful attention. Its mode of formation behind the neck of the pancreas is to be noted, and its mode of termination at the right extremity of the portal fissure of the liver, where it presents the portal sinus, is to be shown, with the cystic vein joining its right branch. The sources from which the vena portæ receives its blood should be thoroughly mastered. The common bile-duct is next to be studied. Its formation by the union of the hepatic duct with the cystic duct is to be dissected, and the hepatic duct itself is to be shown as formed by the union of two ducts, one issuing from the right, and the other from the left, lobe of the liver. The duct is to be followed down in front of the foramen of Winslow, behind the first part of the duodenum, and between the head of the pancreas and the second part of the duodenum on their posterior aspect, to about as low as the junction of the upper two-thirds and lower third of the second part. Its mode of termination in the interior of the second part will fall to be noted when the duodenum is opened for inspection.

The liver is now to be removed, in doing which the inferior vena cava should be ligatured below it, and then divided. It must also be divided above the liver, close to the diaphragm. The viscus is then to be thoroughly studied in all its aspects, and so also is the gall-bladder, the interior of which is to be examined to display the reticulated mucous membrane. An effort should be made at this stage to display the right and left pneumogastric nerves as they enter the abdomen through the œsophageal opening of the diaphragm. The right nerve may be followed to the posterior surface of the stomach, and the left to the anterior surface. The stomach, duodenum, pancreas, and spleen are then to be removed *en masse*, the œsophagus having been previously tied below the seat of division. These organs are now to be carefully studied. After washing out the stomach and duodenum, they are to be opened and their interior examined. The main pancreatic duct, or duct of Wirsung, is to be shown by dissecting the pancreas from behind, and an effort should be made to find the small pancreatic duct, or duct of Santorini, in the head of the gland. The junction of the duct of Wirsung with the common bile-duct in the duodenal wall is to be displayed, and the common internal opening of the two ducts is to be examined. The spleen is to be studied, and sections of it should be made and washed, with pressure, under a stream of water, in order to remove the pulp, and show the trabecular framework.

Posterior Wall of the Abdomen.

The prevertebral sympathetic plexuses, namely, the epigastric or solar and hypogastric, with their secondary offshoots, are to be carefully dissected. The dissector will find the great splanchnic nerve piercing the crus of the diaphragm, and it will guide him to the semi-lunar ganglion. These ganglia, two in number, lie at either lateral pole of the solar plexus, close to each suprarenal capsule, that of the right side being under cover of the inferior vena cava. The lower part of each ganglion will be found to be semi-detached as the aortico-renal ganglion, which lies over the root of the renal artery, and terminating in this ganglion will be found the small splanchnic nerve, after it has pierced the crus of the diaphragm. The least splanchnic nerve, if present, may pierce the crus, or it may pass behind the ligamentum

arcuatum internum, to terminate in the renal plexus. Passing inwards from each semilunar ganglion a matted leash of nerve-fibres, mixed with minute ganglia, is to be dissected. These fibres meet in front of the aorta, and invest the cœliac axis and root of the superior mesenteric artery, in which latter situation is the superior mesenteric ganglion. The offshoots from the solar plexus to be shown are as follows: inferior phrenic; cœliac, furnishing gastric, splenic, and hepatic; superior mesenteric; capsular; renal; aortic; spermatic (ovarian in the female); and inferior mesenteric. The spermatic plexus will be seen to come from the renal and aortic plexuses, and the aortic plexus is to be shown in two halves, right and left, which communicate freely with each other over the front of the aorta. The inferior mesenteric plexus will be found to arise chiefly from the left half of the aortic plexus, and the inferior mesenteric ganglion is to be looked for in it, near the root of the artery of that name. The various secondary plexuses will be found to accompany the corresponding branches of the abdominal aorta. The two halves of the aortic plexus, reinforced by branches from the ganglia of the lumbar sympathetic chains, are to be followed over the common iliac arteries, after which they will be found to blend, in the angle between these vessels, to form the hypogastric plexus. This latter is to be shown dividing into the right and left pelvic plexuses.

Attention is next to be directed to the kidneys and suprarenal capsules. The adipose tunic of the kidney is to be carefully removed, and the suprarenal capsule preserved on the upper part of the organ. The great vascularity and copious nerve-supply of the suprarenal capsule are to be noted, and only one vein is to be looked for, emerging from each through an anterior hilum, that of the right side opening into the inferior vena cava, and that of the left into the renal vein of that side. The structures at the hilum of the kidney are to be shown, and the relations of the organ carefully studied, the visceral areas on the anterior surface of each being noted. The inferior vena cava is next to be dissected, and its tributaries shown, one of these on the right side being the spermatic, or ovarian, vein, whilst the vein of the left side, in each sex, is a tributary of the left renal. The abdominal aorta and its branches are to be dissected, followed by the common iliac vessels. Along the front of the aorta the median lumbar glands should be looked for, and along each common iliac artery the so-called common iliac glands. By drawing aside the right crus of the diaphragm, the receptaculum chyli will be found on the right of the aorta, in front of the first and second lumbar vertebræ, and, on the right of it, the right azygos vein. The ureter is to be dissected as low as the pelvic brim, and the pelvis at its upper end is to be shown. The renal vessels are to be studied, and the kidney is then to be removed. The organ is to be divided into two halves by a vertical incision carried from the outer to the inner border. This will show the fibrous capsule (which should be stripped off), sinus, calices, Malpighian pyramids, and cortex.

The diaphragm is next to be dissected. Its central tendon, crura, ligamenta arcuata, and openings are to be studied. The iliac fascia is next to be dissected, with its upward prolongation on the psoas magnus, known as the psoas fascia. Its mode of attachment to the vertebral column and pelvic brim are to be noted, and its disposition at the outer border of the psoas magnus above the iliac crest is to be carefully studied. The nerves on the posterior wall are now to be shown. Emerging from beneath the ligamentum arcuatum externum, and passing along the lower border of the twelfth rib, will be found the anterior primary division of the twelfth thoracic nerve (subcostal nerve), and with it the subcostal vessels. The genito-crural nerve pierces the psoas magnus close to its inner border, singly or in two branches, genital and crural, and these are to be followed, the former to the cremasteric muscular covering of the spermatic cord, and the latter to Poupart's ligament, beneath which it escapes on to the front of the thigh, close to the outer side of the external iliac artery. The ilio-hypogastric and inguinal nerves appear at the outer border of the psoas magnus, and cross the quadratus lumborum close together, the inguinal being the lower of the two. The external cutaneous nerve also appears at the outer border of the psoas magnus below

the preceding, and is readily recognised by crossing the iliac fossa to a point beneath the outer end of Poupart's ligament, where it passes out to the thigh. The anterior crural nerve will be found lying deeply in the groove between the psoas magnus and iliacus, and the obturator nerve will be found lying deeply on the inner side of the psoas magnus, on its way to the lateral wall of the pelvis. If an accessory obturator nerve is present, it will usually be found passing deeply along the inner side of the psoas magnus, close to the pelvic brim, and then coursing over the superior pubic ramus, where it passes beneath the pectineus.

The psoas magnus is now to be dissected, and a psoas parvus is to be looked for. The nerves are then to be followed upwards and inwards to their origins, by cutting through the psoas magnus. In this manner the lumbar plexus will be exposed, which should be carefully dissected, the lumbo-sacral cord being shown, at the same time, descending to take part in the sacral plexus. The gangliated cord of the sympathetic is to be displayed in front of the bodies of the lumbar vertebræ, and the length of its rami communicantes, which accompany the lumbar arteries, is to be noted. The lumbar branches of the aorta are now to be dissected as far back as the intervals between the lumbar transverse processes, where the lateral lumbar glands should be looked for. If the lumbar veins have not been previously dissected, this should now be done. In connection with these veins, at either side, the ascending lumbar vein is to be shown, that of the right side ending as the right azygos vein, and that of the left side ending as the lower left azygos vein. The posterior aponeurosis of the transversalis abdominis and the quadratus lumborum are next to be dissected, and, if that muscle is cut, it will be seen to be encased in a sheath which is formed by the anterior and middle laminæ of the aponeurosis. The iliacus muscle and the external iliac vessels are now to be dissected, and the relation of the vessels to the peritoneum, subperitoneal tissue, and iliac fascia is to be carefully noted, as well as their relation to the genito-crural nerve and constituents of the spermatic cord. The principal branches of the artery, namely, the deep epigastric and deep circumflex iliac, are to be shown, and related to the artery will be found the external iliac glands, three of them being placed just above Poupart's ligament, one on the outer side, another on the inner side, and a third in front of the vessel. The deep circumflex iliac artery is to be followed behind the outer half of Poupart's ligament, and along the iliac crest, and its anastomoses are to be studied. The lacunar region, which lies between Poupart's ligament and the front of the hip-bone, is to be examined, and its two muscular lacunæ, outer and inner, with the vascular lacuna in front of them, are to be shown, with the structures lying in each.

Pelvis.

The pelvis is to be separated by cutting through the disc between the third and fourth lumbar bodies, and then applying the saw. The various muscles connected with the exterior having been trimmed, the bladder is to be partially inflated, and the general position of the viscera and their relations are to be studied, as far as possible, *in situ*. The extent of the pelvic colon is to be noted, and its extensive mesentery, with the superior hemorrhoidal vessels between its two layers, observed.

The reflections of the peritoneum are then to be examined. If a male subject, the relation of the peritoneum to the bladder is to be thoroughly mastered, and the false ligaments, which it forms for the viscus, noted. The recto-vesical pouch of the peritoneum is also to be observed. If a female subject, the relation of the peritoneum to the uterus is to be studied, and the recto-uterine pouch, or pouch of Douglas, is to be carefully examined, which usually contains a few coils of the ileum, and, it may be, a prolapsed ovary. The broad ligament of the uterus, formed by two layers of peritoneum, is to be studied. The position of the Fallopian tube along its upper border, of the ovary with its ligament in a backward extension of it, and of the round ligament of the uterus in a forward extension of it, are to be observed.

The exact position of the ovary should receive special attention, and the corpus fimbriatum of the Fallopian tube, with its ovarian fimbria, is to be noted.

The peritoneum is now to be stripped from the walls of the pelvis to expose the pelvic fascia. On the lateral wall of the cavity the obturator vessels and nerve are to be shown on their way to the obturator canal, through which they pass. The pelvic fascia is then to be carefully examined. This fascia will be seen to line the lateral wall, where it covers the obturator internus, and the posterior wall, where it forms the fascia of the pyriformis. To see it in front, the bladder must be drawn well backwards. The lining portion of the fascia is called the parietal pelvic fascia. To study it more fully the dissector should remove a large part of the os innominatum by means of the following cut: place the saw over the back part of the iliac crest and over the pubic bone, keeping as near as possible to the pelvic brim, but external to it. The bone is now to be sawn downwards in such a manner as to remove a large part of the tuber ischii, but the great and small sciatic notches are to be avoided. The obturator externus muscle is then to be carefully removed from the outer surface of the obturator membrane, and the obturator artery is to be shown in two branches, which form a loop upon the membrane round its circumference. The obturator membrane is then to be removed, which will expose a portion of the obturator internus.

When this part of that muscle is taken away, a good view of the parietal pelvic fascia from the outside will be obtained through the obturator foramen. The thickened portion of the fascia, known as the white line, is to be observed extending from near the lower part of the symphysis pubis to the spine of the ischium. On looking deeply into the pelvic cavity, the bladder having been well displaced to one side, the parietal pelvic fascia, along the white line, will be seen to send inwards its visceral layer, and the portion of the parietal fascia below the white line will be seen, from the perineal point of view, to line the outer wall of the ischio-rectal fossa, where it contains Alcock's canal. From the under aspect of the white line the levator ani muscle arises, and immediately below this the parietal pelvic fascia gives off the anal fascia, which covers the perineal surface of the levator ani. The dissector will now understand what structures separate the pelvic cavity, on either side of the bladder, from the ischio-rectal fossa, this partition being formed, from above downwards, by the visceral pelvic fascia, the levator ani, and the anal fascia.

At the upper part of the obturator foramen the parietal pelvic fascia should be shown, on the side not yet dissected, to join the upper border of the obturator membrane over the obturator internus muscle, thus converting the obturator groove on the under surface of the superior pubic ramus into a fibro-osseous tunnel, called the obturator canal. Through this canal the obturator vessels and nerve will be seen to pass, and it will be evident that the obturator artery escapes from the pelvic cavity without piercing the parietal pelvic fascia. As the parietal fascia is attached along the ischio-pubic ramus, at either side, it is continued inwards until it meets with the urethra. This portion of it, with its fellow, forms the postero-superior layer of the triangular ligament. From the urethra the fascia is continued backwards over the anterior border of the levator ani to the prostate gland, where it becomes continuous with the visceral layer of the fascia, which ensheathes that gland.

The visceral layer of the fascia is now to be followed inwards to the bladder, rectum, and prostate gland. Opposite the vesicula seminalis it divides into an upper or vesical, a middle or recto-vesical, and a lower or rectal layer, the vesical layer forming the lateral true ligament of the viscus. Opposite the prostate the visceral fascia divides into prostatic, recto-prostatic, and rectal layers. In the female the visceral fascia divides into four layers, namely, vesical, vesico-vaginal, recto-vaginal, and rectal. The bladder being pulled well backwards, two stout bands of the visceral pelvic fascia will be seen to extend from the lower part of the body of each pubic bone over the anterior surface of the prostate gland to the bladder. These constitute the anterior true ligaments of the bladder, and each will be found to contain some of its external longitudinal muscular fibres. Between these two ligaments a well-

marked depression, occupied by fat, is to be shown. To facilitate this dissection, the pelvic brim may be removed on one side.

The prostate gland is now to be exposed, and the anterior fibres of the levator ani shown on its side. Within its fascial sheath will be found the prostatic venous plexus, which receives the dorsal vein of the penis in two divisions. If the subject is a female, a portion of the vagina is to be shown. The ureter, vas deferens, and obliterated hypogastric artery are to be displayed, and their relations noted. The ureter will be found on the lateral wall of the pelvis in front of the internal iliac artery, and, as it curves inwards to the lateral angle of the bladder, it will be seen to be crossed by the vas deferens. In the female, before reaching the bladder, it should be shown to lie on the side of the extravaginal portion of the cervix uteri, and for a short distance on the lateral wall of the vagina at its upper part. The obliterated hypogastric artery will be found passing forwards from the anterior division of the internal iliac artery over the lateral wall of the pelvis towards the apex of the bladder. Thereafter the internal iliac artery and its branches are to be dissected, as follows: from the anterior division, the pervious portion of the obliterated hypogastric, giving off two or three superior vesical arteries; inferior vesical, usually giving off middle hemorrhoidal; obturator; internal pudic; and sciatic; and, from the posterior division, the ilio-lumbar; two or three lateral sacral; and gluteal. The special branches in the female are the uterine and vaginal arteries. The arteries are accompanied by offshoots from the pelvic sympathetic plexus.

In dissecting the branches of the artery, care is to be taken of the nerves which arise from the sacral plexus. By displacing the viscera, this plexus and its branches are to be dissected, including the lumbo-sacral cord. In dissecting the plexus, the nerves which form the lumbo-sacral cord, the cord itself, and the first two sacral nerves are to be shown, by careful dissection, in two divisions, ventral and dorsal, and the third sacral (nervus bigeminus) is to be shown dividing into an upper and a lower branch. The fourth sacral is a nervus furcalis. The sciatic and pudic bands of the plexus are to be displayed. The branches will be found to arise as follows: superior gluteal, by three roots from the dorsal divisions of the descending branch of the fourth lumbar, the fifth lumbar, and the first sacral; inferior gluteal, by three roots from the dorsal divisions of the fifth lumbar, and first and second sacral; muscular branches to the pyriformis, from the dorsal divisions of the first and second sacral; nerve to the obturator internus and gemellus superior, by three roots from the ventral divisions of the fifth lumbar, and first and second sacral; nerve to quadratus femoris and gemellus inferior, from the ventral divisions of the descending branch of the fourth lumbar, fifth lumbar, and first sacral; visceral branches to the bladder, from the third and part of the fourth sacral; small sciatic, by three roots from the posterior aspect of the first, second, and third sacral; perforating cutaneous, by two roots from the posterior aspect of the second and third sacral; great sciatic, which is the continuation of the upper or sciatic band of the plexus; and pudic, which is the continuation of the lower or pudic band. The sacro-coccygeal plexus, formed by part of the fourth sacral, fifth sacral, and coccygeal nerves, is to be dissected, and the pelvic sympathetic cord is to be displayed with the ganglion impar on the first coccygeal vertebra. The middle and lateral sacral arteries are to be followed out, and an effort should be made to show the coccygeal gland of Luschka near the tip of the coccyx. Branches of the middle sacral artery may help to guide the dissector to it. The pyriformis, levator ani, and coccygeus muscles are to be dissected, and the relation of the latter two to the pelvic floor is to be noted. The obturator internus is also to be studied.

Viscera of the Pelvis.—The position of the rectum, and its relations to the bladder and prostate gland in the male, and uterus and vagina in the female, having been studied as far as possible *in situ*, the viscera are to be removed *en masse* along with the superior hemorrhoidal vessels. The bladder, if empty, should be partially inflated, and the rectum and anal canal slightly distended with tow, as well as the vagina, if the subject is a female. The relations of the

rectum are now to be more fully examined, after which the gut is to be separated from the other structures, and subjected to a special dissection. The superior hemorrhoidal artery is to be followed out in two divisions, laterally disposed. The tow having been removed, and one end securely tied, the gut is to be inflated from the other end, which is then to be ligatured. The arrangement of the longitudinal and circular muscular fibres are to be shown, and the thickening of the latter along the anal canal, which gives rise to the internal sphincter, is to be noted. The gut is now to be laid open from end to end, and its interior examined. The valves of Houston, three in number, are to be looked for as transverse crescentic folds. One will be found on the right side fully 3 inches above the anus, and two on the left side about 1 inch above and below the right valve. The part of the bowel surrounded by the internal sphincter muscle is to be studied as the anal canal. The longitudinal folds seen here, called the columns of Morgagni, are to be examined, and a little above the anus these columns will be seen to be connected by circularly-disposed semilunar folds, known as the anal valves. The entire blood-supply of the rectum should be carefully revised.

The bladder is next to be dissected, showing the ureters at the lateral angles, and the vesiculæ seminales and vasa deferentia at the fundus. The commencement of each common ejaculatory duct is also to be shown, this being formed by the union of a vesicula seminalis and vas deferens. The limited area on the fundus, bounded on either side by these structures, and called the external trigone, is to be studied. The peritoneum having been removed from the upper surface of the bladder, the muscular fibres of the viscus are to be displayed as well as possible. They will be found to be arranged as an external longitudinal, a middle circular, and an internal longitudinal, layer, the last being very indefinite. The fibrous cord, representing the urachus, is to be shown passing from the apex of the bladder. The prostate gland is now to be fully examined, and, if not previously dissected, its recto-vesical capsule and the prostatic venous plexus are to be shown. At the base of the gland the dissector should look for the middle lobe, which is represented by the small part lying between the common ejaculatory ducts and the wall of the bladder, the rest of the organ being disposed as two lateral lobes. The membranous part of the urethra is to be shown succeeding to the apex of the prostate gland. A vesicula seminalis may now be cut into, in order to show the reticulated arrangement of its mucous lining. The bladder is to be opened, and its interior carefully examined. The openings of the ureters and the urethral opening are to be noted, and the smooth internal trigone examined, which lies within ridges connecting these openings. The prostate gland is also to be laid open along its anterior surface, and the whole penis is to be laid open, so as to expose the interior of the corpora cavernosa, and the urethra contained in the corpus spongiosum. In the prostatic urethra the central dilatation and the constriction at either end are to be observed, as well as the following markings: the crest, along the posterior wall; the sinus pocularis, having on the lateral margins of its opening, or just within them, the openings of the common ejaculatory ducts; and the prostatic sinus, on either side of the crest, in which the prostatic ducts open. The spongy urethra is next to be examined, and the dilatation towards its centre, and also in the glans, are to be observed, the latter being called the fossa navicularis. The openings of the glands of Littré and the lacunæ of Morgagni are to be noted. The septum pectiniforme of the corpora cavernosa, and their trabecular tissue, which supports the erectile tissue, are to be observed.

In the female the bladder is to be examined as in the male. The absence of a prostate gland is to be noted, and the urethra is to be laid open, its shortness and distensibility being observed. The vagina is to be opened from end to end by an incision along the lateral wall. Its mucous rugæ are to be examined, as well as the carunculæ myrtiformes at its external orifice, and the lower part of the cervix uteri, which is received into its anterior wall at the upper end. The transverse slit of the os uteri externum is to be studied, along with its anterior and posterior lips. The recesses formed by the vagina around the lower part of the cervix uteri, called the fornices, are to be

explored, and, on introducing the finger into the posterior fornix, the dissector will find that he can palpate the recto-uterine pouch of peritoneum or pouch of Douglas. The uterus is next to be carefully examined, and its relations, peritoneal included, are to be revised. The fundus, body, isthmus, and cervix are to be attended to. On each side of the upper part of the vagina and cervix uteri a collection of fat, called the parametrium, is to be shown. The body of the uterus is now to be laid open from before by a triangular incision, the apex of which is on a level with the isthmus, whence the two limbs diverge upwards and outwards to each lateral angle. The thick, triangular flap of the anterior wall thus formed having been raised, the cavity of the body is to be examined. The smoothness of the mucous lining is to be observed, and the uterine openings of the Fallopian tubes at each lateral angle, as well as the os uteri internum at the isthmus, are to be studied. The cervix is then to be opened along its anterior wall on one side of the middle line, and the arrangement of the mucous membrane, known as the arbor vitæ uterina, is to be noted. The Fallopian tube, with the corpus fimbriatum at its outer end, is to be studied, followed by the round ligament of the uterus. The ovary is next to be fully examined, and the scarred condition of its surface noted. The part of the broad ligament between the ovary and Fallopian tube, called the meso-salpinx, on being held up to the light, may be seen to contain the epoöphoron (paro-varium, or organ of Rosenmüller). In a young subject a few other tubules may be seen nearer the uterus, which are known as the paroöphoron. The ovarian and uterine arteries, if injected, are to be followed to their distribution.

Articulations of the Pelvis.—The sacro-vertebral joint is to be examined, and the sacro-vertebral and ilio-lumbar ligaments dissected. The symphysis pubis is to receive careful attention, and the oblique direction of the joint is to be noted. Its ligaments are to be shown, and the interarticular fibro-cartilage is to be examined. Occasionally an interspace will be found in it towards the upper and back part, in which there may be a little fluid. The movement at this joint is only of a very slight yielding nature, except in the female during parturition. The sacro-iliac joint or synchondrosis is next to be examined. Its anterior ligament is weak. The posterior ligament, however, which is to be studied by partially separating the bones, is of considerable strength, and the part which it takes in supporting weight is to be carefully studied. The great and small sacro-sciatic ligaments are to be studied, and the manner in which they convert the sciatic notches on the posterior border of the hip-bone into foramina is to be noted. The dissector is to observe the cartilaginous facing of the small sciatic notch, and the grooves, with intervening ridges, which it presents, for the columns on the under surface of the tendon of the obturator internus. Finally, the sacro-coccygeal and intercoccygeal joints are to be examined.

THE THORAX

Thoracic Wall.

Muscles—Intercostal Muscles.—These are two in number in each space, external and internal, and they are arranged as thin sheets of obliquely-disposed muscular fibres, with a large admixture of tendinous fibres.

External Intercostal Muscles—*Origin.*—The lower border of the upper rib.

Insertion.—The outer margin of the upper border of the lower rib.

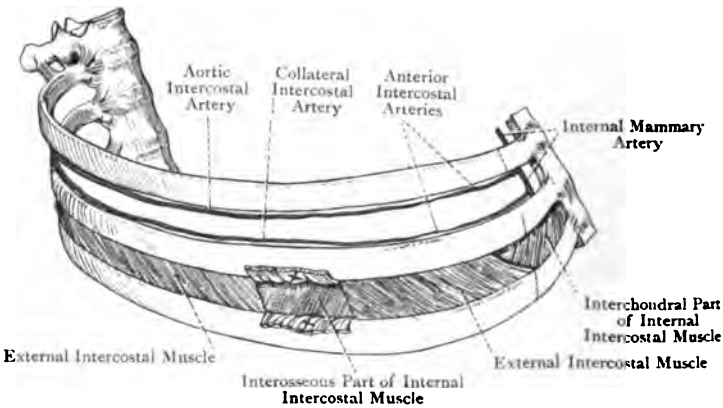


FIG. 367.—DIAGRAM OF THE INTERCOSTAL MUSCLES AND INTERCOSTAL ARTERIES

(A small portion of the external intercostal muscle has been divided and reflected).

Nerve-supply.—The intercostal nerve of the corresponding space.

The fibres of each muscle are directed downwards and forwards, and in this respect coincide with those of the obliquus externus abdominis. The muscles, as a rule, extend as far forwards as the junction of the ribs with their cartilages, but sometimes they stop short of this point, especially in the upper spaces. From the

point where the fibres cease the upper six muscles are continued inwards to the side of the sternum by a thin delicate membrane, called the *anterior intercostal aponeurosis*. This occupies the spaces between the true costal cartilages. Posteriorly the muscles extend as far as the tubercles of the ribs.

Internal Intercostal Muscles—*Origin.*—The upper margin of the subcostal groove of the upper rib.

Insertion.—The inner margin of the upper border of the lower rib.

Nerve-supply.—The intercostal nerve of the corresponding space.

The fibres of each muscle are directed downwards and backwards, and in this respect coincide with those of the obliquus internus abdominis. The upper six muscles extend as far inwards as the side of the sternum, and the lower two are continuous anteriorly with the obliquus internus abdominis. Posteriorly the muscles extend as far back as the angles of the ribs. In this situation each is replaced by a delicate membrane, called the *posterior intercostal aponeurosis*, which lines the adjacent portion of the external intercostal muscle, and blends behind with the anterior or external superior costo-transverse ligament. The internal intercostal muscles are covered internally by the parietal pleura.

Action of the Intercostal Muscles.—This subject has given rise to much discussion and difference of opinion. Three views are entertained. (1) According to Haller, the external and internal intercostal muscles both act as elevators of the ribs, and are therefore muscles of inspiration. Inasmuch as the fibres of the two muscles decussate, they must, according to this view, act on the principle of the parallelogram of forces. The common nerve-supply of the two muscles tends to favour this view. (2) According to Hamberger, the external intercostal muscles are elevators of the ribs, and therefore muscles of inspiration, whilst the internal intercostal muscles are depressors of the ribs, and therefore muscles of expiration. (3) According to Hutchinson, the external intercostal muscles and the *interchondral portions* of the internal intercostal muscles act as elevators of the ribs, and are therefore muscles of inspiration, whilst the *interosseous portions* of the internal intercostal muscles act as depressors of the ribs, and are therefore muscles of expiration.

When a rib is elevated, its lower border is at the same time everted.

For the levatores costarum muscles, see p. 277.

Intercostal Nerves.—These are eleven in number on each side, and are the anterior primary divisions of the upper eleven thoracic spinal nerves. The anterior primary division of the twelfth thoracic spinal nerve is not an intercostal nerve, but lies along the lower border of the twelfth rib, and is known as the subcostal nerve ('last dorsal nerve').

The lower five intercostal nerves ultimately leave the intercostal spaces and pass on to the anterior abdominal wall.

Upper Six Intercostal Nerves.—Each of these nerves, as it enters the back part of an intercostal space, lies between the posterior

intercostal aponeurosis and the parietal pleura. About the level of the angle of the rib it pierces the posterior intercostal aponeurosis, and passes forwards in the subcostal groove of the upper rib, lying between the intercostal muscles. It continues its forward course in this position, in company with the aortic intercostal artery and intercostal vein, the order of these from above downwards being intercostal vein, aortic intercostal artery, and intercostal nerve. The nerve is concealed by the overlapping lower border of the upper rib. Having reached a point about midway between the vertebral column and the side of the sternum, the nerve gives off

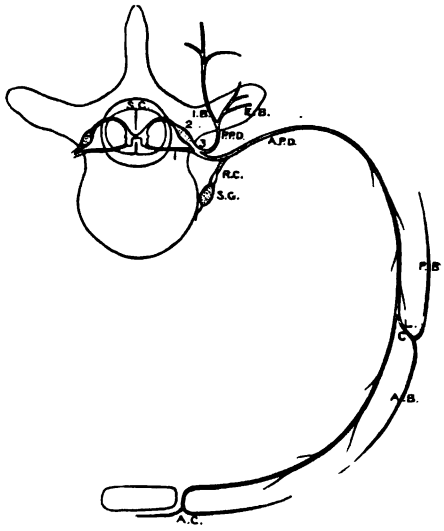


FIG. 368.—SCHEME OF AN INTERCOSTAL NERVE.

S.C. Spinal Cord
1. Anterior Root of Spinal Nerve
2. Posterior Root, with Ganglion
3. Spinal Nerve
A.P.D. Anterior Primary Division (Intercostal Nerve)
S.G. Sympathetic Ganglion
R.C. Rami Communicantes
L.C. Lateral Cutaneous Nerve
A.B. Anterior Branch
P.B. Posterior Branch
A.C. Anterior Cutaneous Nerve
P.P.D. Posterior Primary Division
E.B. External Branch
I.B. Internal Branch

a large branch, called the lateral cutaneous nerve. The intercostal nerve itself, now reduced in size, leaves the intermuscular space hitherto occupied by it, and enters the internal intercostal muscle, in the substance of which it continues its forward course.

Having arrived at the anterior extremity of the osseous rib, the nerve emerges from the internal intercostal muscle and passes inwards on its deep surface, lying at first upon the parietal pleura, and subsequently upon the triangularis sterni muscle, crossing in its course the internal mammary vessels. On reaching the side of the sternum it passes straight forwards, to become an anterior

cutaneous nerve, piercing in succession the following structures : the interchondral portion of the internal intercostal muscle ; the anterior intercostal aponeurosis ; the pectoralis major muscle ; and the deep fascia.

Branches.—These are muscular, lateral cutaneous, and anterior cutaneous.

The *muscular branches* supply the following muscles : the levatores costarum, serratus posticus superior, subcostal muscles, intercostal muscles, and triangularis sterni.

The *lateral cutaneous nerves* arise about midway between the vertebral column and the side of the sternum. They pierce the external intercostal muscles, and make their appearance between the digitations of the serratus magnus (see p. 279). The first intercostal nerve, as a rule, gives off no lateral cutaneous branch, and that of the second is known as the intercosto-humeral nerve.

The *anterior cutaneous nerves* are the terminal branches of the upper six intercostals, that of the first being sometimes absent. For their description, see p. 279.

Intercostal Arteries.—These vessels are arranged in two sets—posterior and anterior.

Posterior Series.—The intercostal arteries of the first two spaces are derived from the *superior intercostal artery* (see p. 952). The intercostal arteries of the lower nine spaces are branches of the descending thoracic aorta, and are called the *aortic intercostal arteries*. Each at first lies between the posterior intercostal aponeurosis and the parietal pleura. About the level of the angle of the rib it pierces the posterior intercostal aponeurosis, and gives off its collateral intercostal branch, which inclines downwards. These two arteries now pass forwards between the two intercostal muscles, the main aortic intercostal lying in the subcostal groove of the upper rib, where it has the intercostal vein above it and the intercostal nerve below it, and the collateral intercostal lying along the upper border of the lower rib. These two vessels, in the case of the upper nine spaces, terminate by anastomosing with the anterior intercostal arteries, which are two in number in each of these spaces, and will be presently described. These anastomoses take place a little in front of the mid-point between the vertebral column and the side of the sternum.

Branches.—These are dorsal, collateral intercostal, and lateral cutaneous.

The *dorsal branch* passes backwards to the muscles and integument of the back, giving off in its course a *spinal branch*, which enters the spinal canal through the intervertebral foramen.

The *collateral intercostal branch*, as stated, arises about the level of the angle of the rib, and inclines downwards to the upper border of the lower rib, along which it passes between the intercostal muscles.

The *lateral cutaneous branch* accompanies the corresponding lateral cutaneous nerve.

The aortic intercostal and collateral intercostal arteries give branches to the intercostal muscles and ribs. Those of the third, fourth, and fifth spaces, at least, furnish branches to the mammary gland and pectoral muscles, which anastomose with the thoracic branches of the acromio-thoracic artery from the first part of the axillary, and with the long thoracic from the second part of that vessel. The first aortic intercostal artery, as it enters the *third* intercostal space, gives off a branch which ascends to the back part of the second intercostal space, and anastomoses with the branch of the superior intercostal artery to that space.

Anterior Series.—The internal mammary artery furnishes two *anterior intercostal arteries* to each of the upper six intercostal spaces, and the musculo-phrenic branch of the internal mammary furnishes two *anterior intercostal arteries* to each of the seventh, eighth, and ninth intercostal spaces. The arteries of the upper six spaces lie at first upon the triangularis sterni muscle, and then upon the parietal pleura, being under cover of the internal intercostal muscle. Afterwards all the anterior intercostal arteries pass between the external and internal intercostal muscles. In each space they anastomose with the aortic intercostal and collateral intercostal arteries, and also with the corresponding intercostal arteries of the upper two spaces.

Branches.—These are distributed to the intercostal muscles, ribs, mammary gland, and pectoral muscles.

The lower two intercostal spaces are not furnished with anterior intercostal arteries. The aortic intercostal arteries of these spaces, after leaving them, enter the abdominal wall, and pass forwards between the internal oblique and transversalis muscles to the rectus abdominis, in which they anastomose with the superior epigastric and deep epigastric arteries.

Intercostal Veins.—These veins accompany the corresponding arteries.

The *chief intercostal vein* passes backwards in the subcostal groove of the upper rib, in company with the aortic intercostal artery, above which it lies. In the region of the angle of the rib it is joined by the *collateral intercostal vein*, which accompanies the corresponding artery. Close to the vertebral column the chief intercostal vein receives a large *dorsal branch*, which returns blood from the muscles and integument of the back, the dorsal spinal venous plexus, and the spinal canal. The mode of termination of the chief intercostal veins differ on each side, and will be described in connection with the dissection of the posterior wall of the thorax.

The *anterior intercostal veins* accompany the anterior intercostal arteries. Those of the upper six intercostal spaces pass to the internal mammary, and those of the succeeding three spaces pass to the musculo-phrenic, veins.

Intercostal Lymphatics.—The lymphatic vessels of the intercostal spaces pass partly to the posterior intercostal glands, which lie at the back parts of the intercostal spaces, and partly to the anterior

intercostal or sternal glands, which lie along the course of the internal mammary artery.

Internal Mammary Artery.—This vessel arises from the lower portion of the first part of the subclavian artery, and it passes downwards, forwards, and inwards behind the inner part of the clavicle and the first costal cartilage. It then descends vertically behind the succeeding costal cartilages as low as the sixth intercostal space, where it terminates by dividing into two branches, namely, the superior epigastric and the musculo-phrenic. The artery lies about ½ inch from the margin of the sternum.

Cervical Relations—*Anterior.*—The clavicular portion of the sterno-cleido-mastoid muscle, and the internal jugular and subclavian veins. The phrenic nerve crosses it superficially from without inwards. *Posterior.*—The dome of the pleura.

Thoracic Relations—*Anterior.*—The pectoralis major; upper six costal cartilages; anterior intercostal aponeuroses; internal intercostal muscles; and upper six intercostal nerves. *Posterior.*—The pleura above, and subsequently the triangularis sterni muscle. *Lateral.*—The artery has a vena comes on either side of it. The anterior intercostal or sternal glands lie along the course of the vessel.

Branches.—The artery gives off no branches in the neck. In the thoracic part of its course it furnishes the following branches:

Superior phrenic.	Anterior intercostal.
Mediastinal.	Perforating.
Pericardial.	Musculo-phrenic.
Sternal.	Superior epigastric.

The *superior phrenic artery*, long and slender, arises high up, and accompanies the phrenic nerve to the diaphragm, from which circumstance it is known as the *comes nervi phrenici*. It gives twigs to the pericardium and pleura, and in the diaphragm it anastomoses with the inferior phrenic branch of the abdominal aorta and with the musculo-phrenic branch of the internal mammary. The *mediastinal branches* are distributed to the contents of the anterior mediastinum, namely, the remains of the thyroid body, anterior mediastinal glands, and areolar tissue. The *pericardial branches* supply the front part of the pericardium. The *sternal branches* are distributed to the sternum and triangularis sterni muscle. The *anterior intercostal arteries* are two in number to each of the upper six intercostal spaces. For their description, see p. 874. The *perforating branches* are six in number, one arising opposite each of the upper six intercostal spaces. Each vessel pierces the internal intercostal muscle, anterior intercostal aponeurosis, and pectoralis major. Thereafter it gives a few twigs to the front of the sternum, and then turns outwards to supply the pectoral integument. The second, third, fourth, and fifth perforating branches give offsets to the inner portion of the mammary gland.

The *musculo-phrenic artery* is one of the terminal branches of the

internal mammary. It arises from that vessel in the sixth intercostal space, and passes obliquely downwards and outwards behind the seventh, eighth, and ninth costal cartilages. About the level of the tenth rib it perforates the diaphragm and terminates in the lateral wall of the abdomen, where it anastomoses with the lateral epigastric branch (ascending branch) of the deep circumflex iliac artery. It gives off anterior intercostal and muscular branches. The anterior intercostal arteries are two in number to each of the seventh, eighth, and ninth intercostal spaces, in which they are

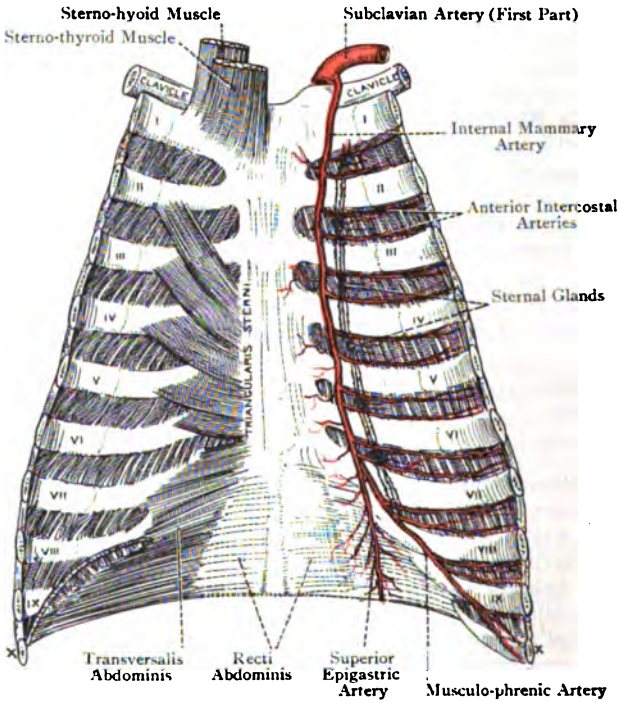


FIG. 369.—DISSECTION OF THE ANTERIOR WALL OF THE THORAX (POSTERIOR VIEW).

disposed in a manner similar to the anterior intercostal branches of the internal mammary. The muscular branches are distributed to the diaphragm and lateral wall of the abdomen. In the diaphragm they anastomose with the inferior phrenic branch of the abdominal aorta and the superior phrenic branch of the internal mammary.

The *superior epigastric artery* is the other terminal branch of the internal mammary, of which it is the continuation. It descends behind the seventh costal cartilage, and passes through the areolar interval between the sternal and costal portions of the diaphragm

In this manner it enters the sheath of the rectus abdominis, lying at first behind the muscle, but afterwards entering it. In the muscle it anastomoses with the deep epigastric artery, which is a branch of the external iliac.

The branches of the superior epigastric artery will be found described on p. 624.

The **internal mammary veins** (*venæ comites*) are two in number, and lie one on each side of the artery. They are formed, respectively, by the union of the venæ comites of the musculo-phrenic and superior epigastric arteries. In their course they receive tributaries corresponding to the branches of the artery. About the level of the first intercostal space the outer vein crosses over the artery and joins the inner vein to form a single vessel, which opens into the corresponding innominate vein. The internal mammary veins are provided with valves at intervals.

Anterior Intercostal or **Sternal Glands.**—These glands are situated along the course of the internal mammary vessels, and are about eight in number. They lie in the intercostal spaces, and they receive their *afferent* lymphatics from the following sources: (1) the inner portion of the mammary gland; (2) the anterior parts of the upper six intercostal spaces; (3) the lymphatics accompanying the superior epigastric artery, which return lymph from the upper part of the anterior wall of the abdomen; and (4) the lymphatics accompanying the musculo-phrenic artery, which return lymph from the anterior parts of the seventh, eighth, and ninth intercostal spaces, and from a portion of the diaphragm. The *efferent* lymphatics of the right glands pass to the right lymphatic duct, and those of the left glands pass to the thoracic duct. Some of the efferent vessels of the lower glands, on each side, become afferent vessels of the anterior mediastinal glands.

Triangularis Sterni—*Origin.*—(1) The deep surface of the ensiform process and body of the sternum, close to the lateral border, and extending as high as the level of the third costal cartilage; and (2) the deep surfaces of the lower two or three true costal cartilages at their sternal ends.

Insertion.—The deep surfaces and lower borders of the costal cartilages from the sixth to the second. The insertion takes place by separate slips, and one or two of the upper slips may be partially attached to the rib itself.

Nerve-supply.—The intercostal nerves of the adjacent spaces.

The lowest fibres of the muscle are horizontal; the succeeding fibres pass obliquely upwards and outwards; and the upper fibres are almost vertical.

Action.—To depress the anterior extremities of the ribs, and so take part in expiration.

The muscle forms a thin musculo-tendinous sheet, which is situated on the deep surfaces of the costal cartilages and side of the sternum, and it is serially continuous with the transversalis abdominis muscle. It supports the internal mammary vessels, sternal

glands, and certain of the intercostal nerves, whilst its deep surface rests upon the parietal pleura.

Thoracic Cavity.

Contents and their General Position.—The thoracic cavity is chiefly occupied by the lungs and heart. The lungs are situated one in each half of the cavity, and each lung is provided with a serous membrane, called the *pleura*. The heart lies obliquely between the lungs, projecting more to the left of the sternum than to the right, and it is enclosed within a fibro-serous sac, called the *pericardium*. Each lung is free to expand except at the *hilum pulmonis*, which is situated on its inner surface. Through this hilum the bronchus, pulmonary artery, and pulmonary veins pass, along with other structures, and the pedicle so formed is called the *root* of the lung. The upper part, or apex, of the lung rises into the root of the neck, where it is covered by the dome of the pleura, that in turn being covered by Sibson's fascia. The lower part, or base, of the lung rests upon the corresponding half of the diaphragm, the heart lying upon the central tendon of that muscle.

The pulmonary artery springs from the base of the right ventricle of the heart, and the aorta from the base of the left ventricle, being at first covered by the pulmonary artery. The left innominate vein courses along the upper aspect of the arch of the aorta in front of the origins of the innominate, left common carotid, and left subclavian arteries, and it unites with the right innominate vein behind the sternal end of the first right costal cartilage to form the superior vena cava. This latter vessel opens into the postero-superior angle of the right auricle of the heart, and, just before piercing the pericardium, it receives the right azygos vein, which arches forwards over the right bronchus. The inferior vena cava, having entered the thorax through the foramen quadratum in the central tendon of the diaphragm, almost immediately opens into the postero-inferior angle of the right auricle of the heart.

The phrenic nerve, on each side, descends in front of the root of the lung, and is intimately related to the pericardium, especially on the left side. The small anterior pulmonary plexus of nerves lies in front of the root of each lung. The pneumogastric nerve, on each side, descends behind the root of the lung, and forms in that part of its course the much larger posterior pulmonary plexus. The following important nerves descend in front of the arch of the aorta : the left phrenic, the left pneumogastric, the upper cervical cardiac branch of the left sympathetic, and the lower cervical cardiac branch of the left pneumogastric. The left superior intercostal vein lies in front of the back part of the aortic arch. The superficial cardiac plexus of nerves lies within the concavity of the arch of the aorta, and the deep cardiac plexus lies behind the arch and in front of the trachea, close to its bifurcation into the two bronchi. The left recurrent laryngeal nerve passes backwards under

the arch, and then ascends behind it. Within the concavity of the aortic arch the trunk of the pulmonary artery breaks up into its right and left divisions, and the ligamentum ductûs arteriosi extends from the root of the left pulmonary artery to the back part of the concavity of the aortic arch, immediately beyond the origin of the left subclavian artery. The gangliated cord of the sympathetic lies very deeply, and descends over the heads of the ribs close behind the parietal pleura, and the two, or three, splanchnic nerves lie obliquely on the sides of the bodies of the lower thoracic vertebræ.

The œsophagus lies in contact with the front of the vertebral column, and the trachea is anterior to it. The descending thoracic aorta lies very deeply, being situated at first on the left side of the vertebral column, but subsequently in front of it. The thoracic duct ascends on its right side, and the right azygos vein ascends on the right side of the thoracic duct, both structures being under cover of the œsophagus. The two left azygos veins, upper and lower, as well as the two transverse azygos veins, upper and lower, are closely related to the vertebral column.

The thoracic cavity contains the following sets of lymphatic glands: the anterior mediastinal, in front of the pericardium; the superior mediastinal, above the pericardium, along the arch of the aorta and innominate veins; the posterior mediastinal, behind the pericardium; the posterior intercostal, in the back parts of the intercostal spaces; and the bronchial, in the interval between the diverging bronchi, and also at the root of each lung. In early life a portion of the thymus body, which is then of large size, lies behind the upper part of the sternum, whence it extends into the lower part of the neck.

Pleuræ.—The pleuræ are the two serous sacs which invest the lungs, and line the adjacent parietes. Each forms a shut sac, which is quite distinct from its fellow. Like other serous membranes, the pleura consists of two portions—parietal and visceral—which, however, are continuous with one another.

The **parietal pleura** lines the parietes, and is divisible into five portions, namely, costal, diaphragmatic, pericardial, cervical, and mediastinal. The *costal pleura* lines the inner surfaces of the ribs and internal intercostal muscles. The *diaphragmatic pleura* covers the upper surface of one-half of the diaphragm. The *pericardial pleura* is in intimate contact with the pericardium. The *cervical pleura* forms what is known as the **dome,** and rises into the neck for about 1 inch above the clavicle, being a little higher on the right side than on the left, on account of the projection formed by the liver. The *mediastinal pleura* of each side bounds the *mediastinum thoracis*.

The **visceral pleura** closely invests the lung, and is known as the *pulmonary pleura*. It is intimately connected with the lung substance, and extends into the fissure, or fissures, which map out the lung into lobes. Below the root of each lung it forms a fold, called the *ligamentum latum pulmonis*, which descends to the diaphragm, and is connected with the pericardium.

Continuity and Reflections of the Pleura.—(1) *In the transverse direction.*—Commencing at the deep surface of the sternum, the parietal pleura of each side passes backwards to the pericardium, the two being in contact except for a little inferiorly. They form the lateral boundaries of the space which is called the *anterior mediastinum.* When they reach the pericardium the two pleuræ separate, each keeping to its own side of that sac, and so forming the pericardial pleura, which bounds laterally the space known as the *middle mediastinum.* Each pleura in this manner reaches the anterior aspect of the root of the corresponding lung, where it becomes the visceral pleura. This covers the front of the root of the lung, and then invests the entire organ, dipping into its fissure or fissures, as the case may be, and giving a covering to the posterior

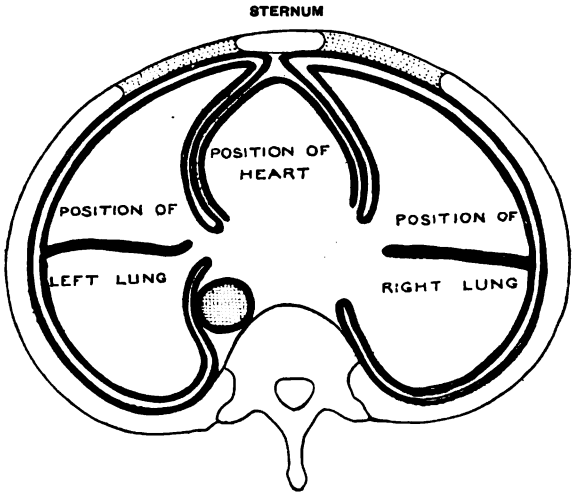


FIG. 370.—DIAGRAM SHOWING THE REFLECTIONS OF THE PLEURÆ (TRANSVERSE SECTION).

aspect of the root. On leaving the back of the root of each lung, the two pleuræ pass backwards, slightly over the pericardium, trachea, and œsophagus, and over the descending thoracic aorta, to the lateral aspects of the bodies of the thoracic vertebræ. These portions form the lateral boundaries of the space which is called the *posterior mediastinum.* From the vertebral column each pleura passes outwards over the gangliated cord of the sympathetic, and then lines the inner surfaces of the ribs, as well as the internal intercostal muscles. In this manner it reaches the deep surface of the sternum.

From the foregoing description it will be evident that the pleura, in passing from the deep surface of the sternum to the vertebral column, meets with, and is reflected over, the lung and its root.

At the level of the manubrium sterni the pleura passes uninterruptedly backwards to the vertebral column. That of the right side passes over the side of the superior vena cava, innominate artery, right innominate vein, and trachea ; whilst that of the left side passes over the side of the left common carotid and left subclavian arteries, œsophagus, and thoracic duct. The two pleuræ, as they pass backwards at this level, form the lateral boundaries of the space which is called the *superior mediastinum.*

Below the level of the root of the lung the antero-posterior reflection of the pleura is complicated by a triangular fold, called the *ligamentum latum pulmonis.* This fold consists of two layers of pleura, in close apposition, which are continuous superiorly with the anterior and posterior pleural investments of the root of the lung. It extends, on the one hand, between the lower border of the root of the lung and the diaphragm, to which latter it is attached, and, on the other hand, between the pericardium and the inner surface of the lung below the level of the root. In the last-named situation its two layers separate, to encase the lung at that level. Its lower border is free and concave.

(2) *In the vertical direction.—Superiorly* the parietal pleura of each side rises, in the form of a dome, into the root of the neck for about 1 inch above the clavicle, where it is covered by *Sibson's fascia.* This fascia is attached, on the one hand, to the internal border of the first rib, and, on the other, to the front of the transverse process of the seventh cervical vertebra. The subclavian artery and innominate vein are intimately related to the dome of the pleura internally and anteriorly, the artery being the higher of the two. *Inferiorly* the parietal pleura of each side is reflected from the thoracic wall on to the upper surface of the corresponding portion of the diaphragm, which it covers where the base of the lung rests upon it. The intervening portion of the diaphragm (central tendon) is covered by the serous portion of the pericardium. Internally the diaphragmatic pleura becomes continuous with the mediastinal pleura.

Lines of Reflection of the Pleuræ—*Sternal Reflection.*—Behind the manubrium sterni the right and left pleuræ are separated from each other by an interspace which represents the *superior mediastinum.* At the level of the junction of the manubrium and body of the sternum they meet each other, and descend behind the body of the bone, in close contact and inclining slightly to the left of the median line. At the level of the lower border of the fourth costal cartilage the *left* pleura parts company with the right, and passes outwards and downwards close to the left border of the sternum, and in intimate relation with the pericardium. There is, however, a small triangular area of that sac which is uncovered by the pleura, and lies in direct relation to the anterior thoracic wall. The left pleura continues its downward course as far as the inner surface of the sixth costal cartilage, lying not far from the left border of the sternum. At this level it again passes outwards and downwards,

to be reflected on to the diaphragm. The *right* pleura pursues an undeviating course downwards behind the sternum as far as the junction of the body and ensiform process. At this level it leaves the bone, and passes obliquely outwards, downwards, and backwards over the inner surface of the seventh costal cartilage, from which it is reflected on to the diaphragm.

Costo-diaphragmatic Reflection.—The level of this reflection may be considered in the first place as it affects certain definite vertical lines. In the left sternal line it takes place at the level of the sixth costal cartilage, and in the right sternal line at the level of the seventh costal cartilage. In the left mammary line it takes place at the level of the eighth costal cartilage, where it joins the osseous part of the rib, and on the right side at a similar level. In the left mid-axillary line it takes place on a level with the lower border of the tenth rib, this being the lowest point to which the pleura descends. In the right mid-axillary line it takes place on a level with the upper border of the tenth rib, or, it may be, the lower border. Posteriorly, in the scapular line (inferior angle of the scapula), on each side, it takes place at the level of the lower border of the twelfth rib. From this point inwards to the vertebral column the line of pleural reflection is a little below the adjacent border of the twelfth rib, and is very nearly midway between the vertebral end of that rib and the first lumbar transverse process.

From the foregoing description it will be evident that the pleura descends lowest in the mid-axillary line, and that posteriorly, close to the vertebral column, it actually descends below the level of the lower border of the twelfth rib. The direction of the line of costo-diaphragmatic reflection, from before backwards, is at first obliquely downwards and outwards, until the level of the tenth rib is reached. Thereafter the line passes backwards and upwards to the vertebral column. The costo-diaphragmatic pleural line is on a distinctly lower level than the margin of the base of the lung, but it is a little above the line of the costal attachment of the diaphragm. The portion of the diaphragm below the line is therefore in direct contact with the thoracic wall and adjacent internal intercostal muscles, without the intervention of the pleura, and the costo-diaphragmatic reflection is connected to these structures by a fascial expansion.

The free surfaces of the parietal and visceral pleuræ are, in health, in close contact. They are polished and moistened by a slight amount of serous fluid, so that they glide smoothly upon each other. In cases of pleurisy, however, certain changes take place. The free surfaces are, in the first place, rendered dry, and thereafter they become roughened at intervals by the deposit of lymph. Under these circumstances the movement of the lung is accompanied by the sound known as pleuritic friction. Adhesions are also frequently formed, and a serous exudation takes place into the pleural sac, which tends to compress the lung injuriously, the condition being known as hydro-thorax. In cases of serous exudation the cavity of the pleura, which is a shut sac, is clearly demonstrable, but in

health no such cavity exists, the parietal and visceral pleuræ being at all times in intimate contact with each other. The attached surfaces of the parietal and visceral pleuræ are roughened by fibrous processes, by means of which they are connected to the parts which they cover.

The costal pleura is the thickest, and can readily be stripped from the inner surfaces of the ribs and internal intercostal muscles. There is a fairly thick layer of subserous areolar tissue on its attached surface. The diaphragmatic and pericardial pleuræ are thinner than the costal pleura, and are more adherent to the subjacent structures. The pulmonary pleura is the thinnest and most adherent. Beneath it there is a layer of subserous areolar tissue, containing much elastic tissue, and this is in continuity with the areolar tissue which pervades the lung.

Differences between the Two Pleural Sacs.—The *right* pleural sac rises higher into the root of the neck, and is shorter and wider, than the *left*. These differences are due partly to the projection formed by the liver on the right side, and partly to the greater inclination of the heart to the left of the sternum than to the right.

Blood-supply.—The *parietal pleura* receives its arteries from (1) the aortic intercostals, and (2) the superior phrenic, anterior intercostal, anterior mediastinal, pericardial, and musculo-phrenic branches of the internal mammary.

The **veins** pursue courses corresponding to the arteries.

Nerve-supply.—The nerves are derived from the sympathetic and phrenic nerves.

Lymphatics.—The pleura and the subserous areolar tissue contain many lymphatic vessels which communicate with the pleural cavity by means of stomata. Those of the parietal pleura pass to the anterior and posterior intercostal glands, whilst those of the visceral pleura are connected with the lymphatics of the lung, which pass to the bronchial glands.

Structure.—The pleura is a typical serous membrane like the serous portion of the pericardium, the peritoneum, and the tunica vaginalis. Such membranes are called *serous* because their free surfaces are moistened by a small quantity of serous fluid. Briefly stated, the pleura consists of a homogeneous, connective-tissue basement membrane, containing elastic tissue, and lined with endothelium. It presents many *stomata*, which communicate with the pleural cavity and with the pleural lymphatic vessels.

Development.—The pleura is developed from the walls of the cœlom, or body-cavity, which is the cleft in the mesoblast separating the splanchnopleure and somatopleure.

Mediastinum Thoracis.—The mediastinum thoracis is formed by the approximation of the two pleural sacs in the region of the median antero-posterior line of the thorax. The interval between the two sacs is called the *mediastinal space*, and its boundaries are as follows : in front, the sternum ; behind, the bodies of the thoracic vertebræ ; and, on either side, the corresponding pleural sac. The mediastinal space contains structures so numerous as to necessitate

its subdivision into four parts—superior, anterior, middle, and posterior.

The **superior mediastinum** is situated above the pericardium, and its **boundaries** are as follows : *in front*, the deep surface of the manubrium sterni, with the origins of the sterno-hyoid and sterno-thyroid muscles ; *behind*, the bodies of the upper four thoracic vertebræ and the lower portions of the longus colli muscles ; *above*, an imaginary plane corresponding to the superior aperture of the thorax : *below*, an imaginary plane passing from the lower border of the manubrium sterni to the lower border of the body of the fourth thoracic vertebra ; and, *laterally*, the mediastinal pleura of each side as it extends from the deep surface of the manubrium sterni to the vertebral column.

Contents.—These are as follows : (1) the arch of the aorta ; (2) the innominate artery, and the thoracic portions of the left common carotid and left subclavian arteries ; (3) the right and left innominate veins, and the upper half, or extrapericardial portion, of the superior vena cava ; (4) the phrenic, pneumogastric, left recurrent laryngeal, and cardiac nerves ; (5) the trachea, œsophagus, and thoracic duct ; 6) the superior mediastinal glands ; and (7) the remains of the thumus body.

The **anterior mediastinum** is situated behind the body of the sternum, and its **boundaries** are as follows : *in front*, the deep surface of the body of the sternum, and the left triangularis sterni muscle ; *behind*, the pericardium ; and, *laterally*, the mediastinal pleura of each side as it extends from the deep surface of the body of the sternum to the lateral aspects of the pericardium. Its direction is downwards and to the left. At its upper part there is no interspace, because the two pleural sacs come into contact behind the first piece of the body of the sternum. Below this level, however, the left pleural sac diverges from its fellow, so as to leave an interspace.

Contents.—These are the anterior mediastinal glands, some lymphatic vessels, the anterior mediastinal branches of the internal mammary artery, and areolar tissue.

The **middle mediastinum** lies behind the anterior, and below the superior, mediastinum, and is the widest part of the interpleural space.

Contents.—These are as follows : (1) the heart, enclosed in the pericardium ; (2) the ascending aorta ; (3) the trunk of the pulmonary artery ; (4) the lower half, or intrapericardial portion, of the superior vena cava ; (5) the phrenic nerves and the superior phrenic vessels ; (6) the bifurcation of the trachea ; and (7) the roots of the lungs.

The **posterior mediastinum** is situated behind the pericardium, and below the posterior part of the superior mediastinum, with which latter it is continuous. Its **boundaries** are as follows : *in front*, the pericardium, and below this the posterior part of the diaphragm ; *behind*, the bodies of the thoracic vertebræ below the level of the lower border of the body of the fourth ; and *laterally*,

the mediastinal pleura of each side as it extends from the back of the root of the lung to the side of the vertebral column.

Contents.—These are as follows: (1) the descending thoracic aorta; (2) the œsophagus, and the two pneumogastric nerves; (3) the thoracic duct; (4) the right azygos vein; (5) the upper and lower left azygos veins, with the corresponding transverse azygos veins; (6) the great splanchnic nerves, right and left; and (7) the posterior mediastinal glands.

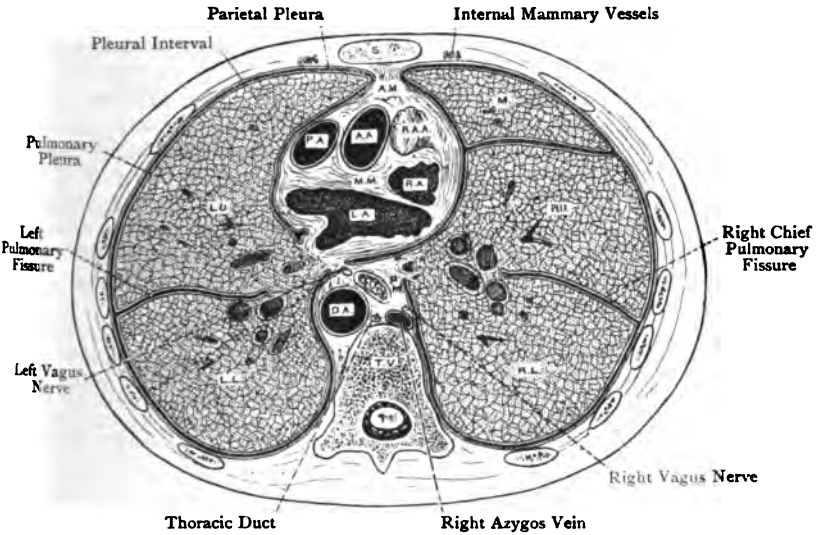


FIG. 371.—TRANSVERSE SECTION OF THE THORAX THROUGH THE SECOND STERNEBRA IN FRONT AND THE BODY OF THE NINTH THORACIC VERTEBRA BEHIND, SHOWING THE REFLECTIONS OF THE PLEURÆ AND THE POSITION OF THE VISCERA.

S. Sternum
A.M. Anterior Mediastinum
A.A. Ascending Aorta
P.A. Pulmonary Artery
R.A.A. Right Auricular Appendix
R.A. Right Auricle
M.M. Middle Mediastinum
L.A. Left Auricle
P.M. Posterior Mediastinum
O. Œsophagus
D.A. Descending Thoracic Aorta
T.V. Thoracic Vertebra
M. Middle Lobe of Right Lung
R.U. Right Upper Lobe
R.L. Right Lower Lobe
L.U. Left Upper Lobe
L.L. Left Lower Lobe

Phrenic Nerve.—This nerve arises chiefly from the anterior primary division of the fourth cervical nerve. It usually receives a small root from the anterior primary division of the third cervical, and, as a rule, an additional root from that of the fifth cervical. Having descended on the superficial surface of the scalenus anticus muscle to the root of the neck, it crosses the internal mammary artery superficially from without inwards. Thereafter it enters the thorax and descends in front of the root of the lung, in close contact with the side of the pericardium, and under cover of the mediastinal

pleura. Having reached the diaphragm, the nerve divides into several branches, which pierce that muscle to be distributed to its abdominal surface. The terminal branches of each nerve are connected, in the diaphragm, with filaments of the corresponding inferior phrenic plexus of the sympathetic, which is an offshoot from the solar plexus. At the place of junction of the two sets of fibres on the right side there is a small ganglion, called the *ganglion diaphragmaticum*. In the thorax the phrenic nerve occupies the superior and middle mediastinal spaces. The *right* phrenic nerve lies, in succession, on the outer side of the right innominate vein and superior vena cava, and then descends in front of the root of the right lung. The *left* phrenic nerve descends in the interval between the left common carotid and left subclavian arteries, where it crosses the left pneumogastric nerve from without inwards. Thereafter it passes behind the left innominate vein, and crosses over the arch of the aorta, after which it descends in front of the root of the left lung. Each nerve is accompanied by the superior phrenic artery, which is a branch of the internal mammary artery.

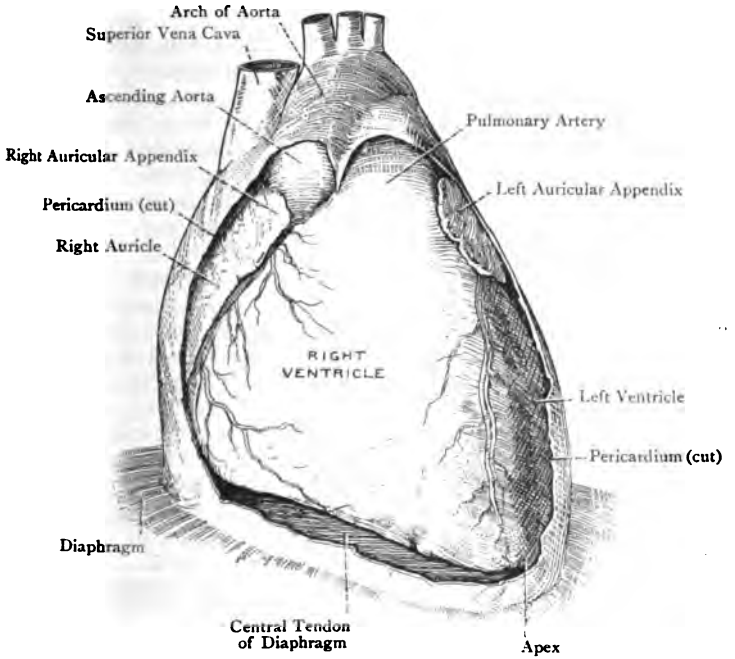
Branches.—The nerve of each side furnishes twigs to the pericardium and the mediastinal pleura, its principal branches being distributed to the diaphragm.

Differences between the two phrenic nerves—(1) The *right* nerve is shorter than the left, because the right half of the diaphragm, having the bulk of the liver below it, is higher than the left half. (2) The *right* nerve is straighter than the left, because the heart, enclosed in the pericardium, projects less to the right side than to the left. (3) The *right* nerve occupies a deeper position in the upper part of the thorax than the left.

Pericardium.—The pericardium is the fibro-serous sac which loosely surrounds the heart in the middle mediastinum. It is somewhat conical, being wide below, where it is in contact with the diaphragm, and narrow above, where it surrounds the great vessels connected with the base of the heart. On each side it is intimately related to the mediastinal pleura, and is embraced by the inner surfaces of the lungs anterior to their roots. The phrenic nerve, on each side, descends in very close contact with it. In front of it are the body of the sternum and the sternal ends of the corresponding costal cartilages. Its anterior surface is, to a greater or less extent, encroached upon by the adjacent portions of the anterior margins of the lungs and by the two pleuræ. There is, however, a small portion of this surface which is immediately related to the sternum below the level of the lower border of the fourth left costal cartilage at its sternal end. Posteriorly, the pericardium lies in front of the posterior mediastinum, and the œsophagus is here related to it opposite the posterior aspect of the left auricle of the heart.

The pericardium consists of two portions—an external or fibrous, and an internal or serous. The **fibrous portion** is strong and dense. Inferiorly it is attached to the central tendon of the diaphragm, and slightly to its muscular part on the left side.

Superiorly it ensheathes the great vessels connected with the base of the heart, with the single exception of the inferior vena cava. These sheaths are eight in number. One, which is the strongest, invests the whole of the ascending aorta ; two invest the right and left pulmonary arteries ; one surrounds the lower half of the superior vena cava ; and the remaining four invest the pulmonary veins. The inferior vena cava receives no sheath from the fibrous portion, because that vessel opens into the right auricle of the heart almost immediately after it passes through the foramen quadratum in the central tendon of the diaphragm.



BEED] FIG. 372.—THE HEART (ANTERIOR VIEW) AND PERICARDIUM

(The anterior part of the pericardium has been removed).

The fibrous layer is attached to the sternum by two fibrous bands, which are known as the *superior* and *inferior sterno-pericardial ligaments* of Luschka, the former being attached to the deep surface of the manubrium, and the latter to the deep surface of the ensiform process.

The **serous portion** is a typical serous membrane, and consists of two layers, parietal and visceral, which together form a shut sac.

The *parietal portion* lines the inner surface of the fibrous part, to which it is closely adherent, and it also intimately covers the upper surface of the central tendon of the diaphragm.

The *visceral portion*, known as the *epicardium*, closely invests the heart, and also the great vessels at its base more or less completely. The continuity between the parietal and serous portions is established inferiorly along the inferior vena cava. Superiorly the continuity is established along the great vessels at the base of the heart about 1½ inches above it. In this situation the serous portion forms an arterial sheath which encloses within it the ascending aorta and trunk of the pulmonary artery, for, as stated, about 1½ inches, this being the only complete sheath formed by the serous portion. Behind this sheath, with its contents, and in front of the auricular portion of the heart, there is a passage, called the *transverse sinus* of the pericardium, which leads from the right to the left side of the serous sac. The serous portion is also related to the superior vena cava and the pulmonary veins, but it only covers them in front and at the sides.

The serous portion of the pericardium forms a triangular fold, called the **vestigial fold of Marshall,** which is situated between the left pulmonary artery and the upper left pulmonary vein. Its base is directed towards the left, and its surfaces are anterior and posterior. Between its two delicate layers there is a small fibrous cord, which is a vestige of the left duct of Cuvier.

The free surfaces of the parietal and visceral layers of the serous portion are smooth, polished, and lubricated by serous fluid to allow of free movement on the part of the heart. In the course of pericarditis they become at first dry, and then roughened by deposits of lymph, thus giving rise to the pericarditic friction murmur, and, it may be, to adhesions. They may also become separated from each other by effusion into the pericardial sac, thus giving rise to the condition known as hydro-pericardium.

Blood-supply.—The fibrous portion of the pericardium and the parietal layer of the serous portion receive their arteries from (1) the pericardial and superior phrenic branches of the internal mammary, and (2) the descending thoracic aorta. The visceral layer of the serous portion receives arterial twigs from the coronary arteries of the heart.

The **veins** pass to the internal mammary, superior phrenic, and azygos veins.

Nerve-supply.—The phrenic, pneumogastric, and sympathetic nerves.

Lymphatics.—These pass to the anterior, superior, and posterior mediastinal glands.

Structure.—The fibrous portion of the pericardium is composed of fibrous tissue, and is very dense, but not very extensible. The serous portion consists of a homogeneous, connective-tissue basement membrane, containing some elastic fibres, and lined with endothelium. The parietal layer is much thicker than the visceral, and the latter is intimately connected with the cardiac muscular tissue, except along the grooves which are occupied by adipose tissue and bloodvessels.

Development.—The serous portion of the pericardium is developed from the walls of the cœlom, or body-cavity, which is the cleft in the mesoblast separating the splanchnopleure and somatopleure.

Thymus Body (Gland).—This body is present only in the fœtus and young child. It attains its greatest size at the period of birth, and forms a very conspicuous object in the dissection of a child during the first year or two of life. It soon, however, begins to diminish. In its fully-developed condition it is situated partly in the thorax, and partly in the neck. In the former situation it occupies the superior and anterior mediastinal spaces, extending as low as about the level of the fourth costal cartilages, and lying in front of the great bloodvessels and upper part of the pericardium, the upper part of the sternum being in front of it. In the neck it extends as high as the lower part of the thyroid body, being under cover of the sterno-hyoid and sterno-thyroid muscles. In this situation it embraces the front and sides of the trachea, completely concealing it from view, and it encroaches upon the carotid sheath on either side. Its length is about 2½ inches, and its breadth, which is greatest inferiorly, is about 1½ inches. Its colour is pinkish; it is soft in consistence; and its surface shows indications of lobulation. It consists of two asymmetrical lateral lobes, each of which is pyramidal. In some cases the left lobe is the larger, and in other cases the right. These lobes are in close contact, but are still quite distinct. Sometimes a third lobe is present, occupying an intermediate position between the other two.

Blood-supply.—The arteries are chiefly derived from the internal mammary, inferior thyroid, and superior thyroid.

The **veins** open into the right and left innominate and thyroid veins.

Nerve-supply.—The nerves are derived from the sympathetic and pneumogastric.

Structure.—Each lobe has a capsule of fibrous tissue, from which trabeculæ pass into the interior. These trabeculæ map out each lobe into large and small lobules. Each lobule consists of an outer cortical, and an inner medullary, portion. The *cortex* is composed of lymphoid tissue, the lymphoid element predominating over the retiform, and it is surrounded by a capillary network of bloodvessels, which contains many lymph corpuscles. The lymphoid tissue of the cortex is incompletely subdivided into nodules by means of trabeculæ.

The *medulla* is more transparent than the cortex, the retiform element of the lymphoid tissue is more conspicuous, and the lymph corpuscles are less numerous. In addition, the medulla contains small groups of cells, more or less concentrically arranged, which are known as the **concentric corpuscles of Hassall.** According to one view these cells are remains of the diverticula from which the thymus body is developed; but another view is that they are concerned with the formation of bloodvessels and connective tissue.

Development.—The thymus body is developed from the pharyngeal hypoblast. It appears as a tubular diverticulum from the third visceral cleft of each side. These diverticula extend downwards on either side of the trachea towards the heart. Their upper parts lose their connection with the pharyngeal hypoblast, and the lower parts undergo a process of budding, and so give rise to the lateral lobes, which come together in front of the trachea. Subsequently the lobes become pervaded by lymphoid tissue.

Thymus Body in the Adult.—Only the remains of the thymus body are present in the form of a collection of adipose and areolar

tissues, which lies in the superior mediastinum in front of the innominate and left common carotid arteries, above the arch of the aorta. This mass receives a few twigs from the mediastinal branches of the internal mammary artery, and it usually contains a certain amount of the original lymphoid tissue.

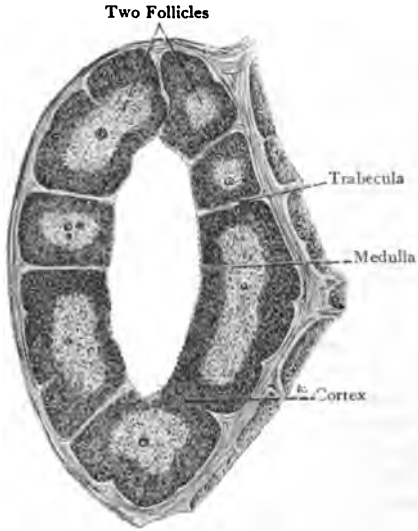


FIG. 373.—TRANSVERSE SECTION OF A LOBULE OF THE THYMUS GLAND OF A KITTEN

(The concentric corpuscles of Hassal are shown in the medulla).

Lungs.—The lungs are two in number—right and left. They are spongy in consistence, float in water, and are readily compressed. When pressed between the fingers crepitation is elicited, this being due to the displacement of air. When the lung is incised, similar crepitation is heard, and a muco-serous fluid, mixed with air, exudes. They possess considerable elasticity, their colour is that of a dark slate, and they are usually mottled, this being due to carbonaceous matter. In early life, however, the colour is rose-pink.

The lungs occupy the greater part of the thoracic cavity. Normally they are at all times in close contact with the thoracic walls, the pleuræ intervening. Unless adhesions have formed during life between the visceral and parietal pleuræ, the surface of each lung is quite free except in two situations, namely, at the root, which occupies a limited area of the inner surface, and at the attachment of the ligamentum latum. Each lung is conical, the base being directed downwards. It presents for consideration an

apex, a base, two surfaces, outer and inner, and two borders, anterior and posterior.

The **apex** is blunt, and rises out of the thoracic cavity into the root of the neck for about 1½ inches. It is here covered by the dome of the pleura, and a little below its highest point it presents a groove on its internal and anterior aspects. In the case of the right lung this groove is produced by the innominate and right subclavian arteries, and, in the case of the left lung, by the subclavian artery of that side. Below this groove there is another

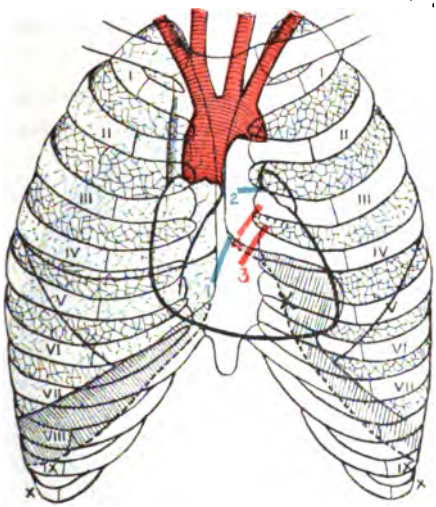


FIG. 374.—DIAGRAM SHOWING THE HEART AND LUNGS IN SITU.

1 Tricuspid Orifice
2 Pulmonary Orifice
3 Mitral Orifice
4 Aortic Orifice
X, Region of Latham's Circle

groove, produced on either side by the innominate and subclavian veins.

The **base** is extensive, semilunar in outline, and concave in adaptation to the upper arched surface of the diaphragm, upon which it rests, with the intervention of the pleura. The base of the right lung is related to the right lobe of the liver, and that of the left lung to the left lobe of the liver, the stomach, and the spleen, the diaphragm intervening in each case. The margin of the base is thin and sharp, and it extends into the costo-diaphragmatic space, reaching lowest behind, but nowhere as low as the line of the costo-diaphragmatic reflection of the pleura.

The **outer surface** is extensive and convex, and in health it is closely applied to the inner surfaces of the ribs and of the internal intercostal muscles.

The **inner surface** is of much more limited extent than the outer.

The greater part of it is concave in adaptation to the heart, enclosed in the pericardium, the concavity being greater in the case of the left lung on account of the projection of the heart to the left side. About the junction of the anterior two-thirds and posterior third this surface presents a vertical fissure, called the ***hilum pulmonis***, at which the root of the lung is situated. The inner surface of the ***right*** lung, behind the hilum, is related to the œsophagus, and the corresponding portion of the inner surface of the left lung presents part of the aortic groove, vertically placed and produced by the descending thoracic aorta. Anterior to the lower part of this groove the left lung is related to the œsophagus, but less

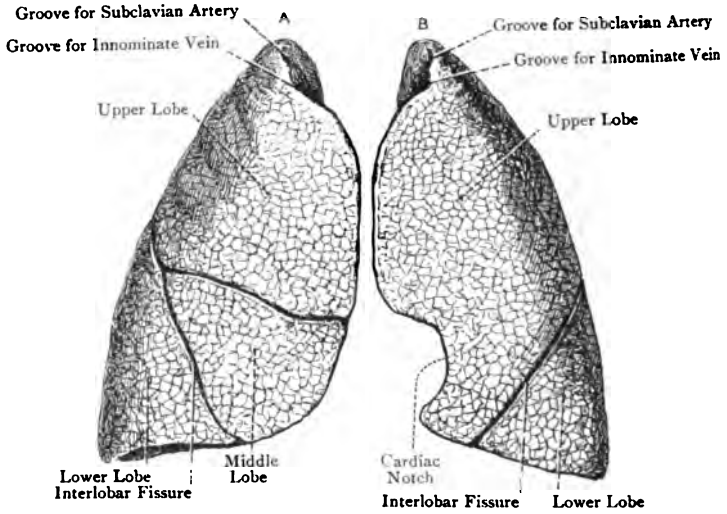


FIG. 375.—THE LUNGS (ANTERIOR VIEW).

A, the Right Lung; B, the Left Lung.

intimately than the right lung. The inner surface of the ***right*** lung presents the following grooves above the level of the hilum, named in order from below upwards: (1) azygos, for the right azygos vein; (2) caval and innominate, for the superior vena cava and right innominate vein; and (3) arterial, for the innominate artery. The inner surface of the *left* lung presents the following grooves above the level of the hilum: (1) the commencement of the aortic groove, transversely disposed, for the arch of the aorta; (2) the subclavian groove, for the left subclavian artery, leading upwards from the preceding; and (3) an indefinite groove, anterior to the subclavian groove, for the left innominate vein.

The **borders** are anterior and posterior. The **anterior border** is thin and short, and overlaps the pericardium, more so during

inspiration than expiration, but leaving an area of the pericardium uncovered, which is known as the area of precordial dulness. The anterior border of the right lung keeps behind the sternum as low as the sixth right costal cartilage. The corresponding border of the left lung, beyond the lower border of the fourth left costal cartilage, presents a deep V-shaped notch, called the *cardiac notch*, for the reception of the apical portion of the heart, enclosed in the pericardium. The **posterior border** is elongated, thick, and round, and it occupies the pulmonary groove of the thorax, by the side of the thoracic portion of the vertebral column.

Each lung is divided into two **lobes,** upper and lower, by an extensive, oblique, and deep fissure, which penetrates almost to the hilum. So deep is this fissure that, unless adhesions have formed, the lung appears to consist of two halves. The fissure commences on the inner surface, near the posterior border, about 3 inches below the apex. It then turns round the posterior border, and passes obliquely downwards and forwards over the outer surface to the basal margin. In the case of the right lung the fissure joins the basal margin some little distance from the lower end of the anterior border; but, in the case of the left lung, the fissure joins the basal margin distinctly farther forwards. A good ready guide to this fissure is the lower border of the pectoralis major muscle, as it forms the anterior fold of the axilla.

The **upper lobe** is comparatively small, and includes the apex, about the upper 3 inches of the posterior border, the anterior border, and, in the case of the left lung, practically all that can be auscultated anteriorly. The **lower lobe** is of large size, and lies behind and below the great pulmonary fissure. It includes the base, the posterior border except the upper 3 inches, and practically all that can be auscultated posteriorly.

By means of the great pulmonary fissure each lung, as stated, is divided into two lobes. In the case of the left lung the division proceeds no further. In the case of the right lung, however, there is an additional fissure, which extends from the chief fissure, at the posterior border, horizontally forwards over the outer surface to the anterior border at about the level of the lower margin of the fourth right costal cartilage, which corresponds to the commencement of the cardiac notch on the anterior border of the left lung. This additional fissure cuts off from the upper lobe a triangular or wedge-shaped portion, which is called the **middle lobe.**

Differences between the two lungs—(1) The *right* lung has two fissures and three lobes, whilst the left lung has only one fissure and two lobes. (2) The anterior border of the *right* lung is uninterrupted, whilst that of the left lung presents inferiorly the cardiac notch. (3) The *right* lung is larger and heavier than the left, the weight of the right being about 20 ounces and that of the left about 18 ounces. (4) The *right* lung is shorter than the left, this being due to the fact that the liver causes the right half of the dia-

phragm to rise higher than the left half. (5) The *right* lung is broader than the left, because the heart projects more to the left side than to the right.

Vertical Extent of the Lungs. — In the mammary line the *right* lung descends as low as the sixth rib ; in the mid-axillary line, as low as the eighth rib ; and, in the scapular line (inferior angle of the scapula), as low as the tenth rib. The lower limits of the *left* lung exceed those of the right by about the depth of a rib.

Root of the Lung.—The root is situated at the ***hilum pulmonis*** on the inner surface. Its chief constituents are as follows : (1) the bronchus or air-tube ; (2) the pulmonary artery, which conveys

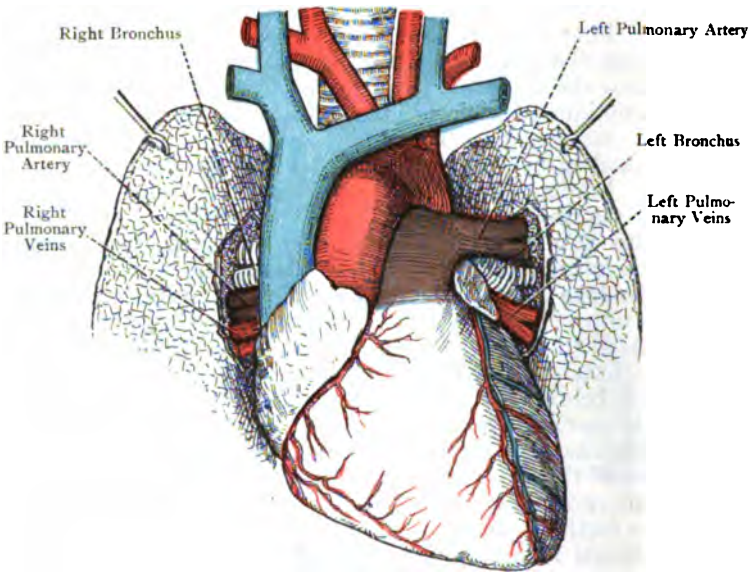


FIG. 376.—THE ROOTS OF THE LUNGS (ANTERIOR VIEW).

venous blood to the lung : and (3) the two pulmonary veins, which convey the arterial or oxygenated blood from the lung to the left auricle of the heart. In addition to these constituents there are (*a*) the bronchial arteries and veins, (*b*) the pulmonary lymphatic vessels, (*c*) the pulmonary nerves, and (*d*) the bronchial lymphatic glands. All these constituents are connected by areolar tissue, and the entire root is invested by the pleura.

Relations.—The following relations are common to both roots : *in front*, the phrenic nerve, with the superior phrenic artery, and the anterior pulmonary plexus of nerves ; *behind*, the pneumogastric nerve and the posterior pulmonary plexus of nerves ; and, *below*, the ligamentum latum pulmonis.

Special Relations — Right Root — *Anterior.* — The superior vena cava and the upper part of the right auricle of the heart. *Superior.*—The right azygos vein, as it arches forwards over the right bronchus to open into the superior vena cava. *Posterior.*—The right azygos vein. **Left Root** — *Superior.*—The arch of the aorta. *Posterior.*—The descending thoracic aorta.

Relative Position of the Chief Constituents.—The relation *from before backwards* is the same on each side, and is as follows : (1) the upper of the two pulmonary veins ; (2) the pulmonary artery ; and (3) the bronchus. The relation *from above downwards* differs on the two sides. On the *right side* the relation is bronchus, pulmonary artery, and pulmonary veins ; and, on the *left side*, pulmonary artery, bronchus, and pulmonary veins.

The difference in the position of the bronchus on each side is due to the fact that the right bronchus gives off a branch known as the *eparterial* bronchus, which lies above the right pulmonary artery, the larger portion of the right bronchus and the whole of the left bronchus being *hyparterial.*

Structure of the Lungs.—The trachea divides into two bronchi, right and left, the structure of which is similar to that of the trachea. The right bronchus, at about $\frac{3}{4}$ inch from its origin, gives off superiorly a branch, called the *eparterial bronchus*, for the upper lobe of the right lung, and beyond this point, where it is now *hyparterial*, it divides into two branches, one for the middle, and the other for the lower, lobe. The left bronchus is entirely *hyparterial*, and divides into two branches, one for the upper, and the other for the lower, lobe of the left lung. The structure of these primary divisions of the bronchi is similar to that of the bronchi themselves. Within each lung these primary divisions undergo subdivision, to a certain extent dichotomously, but the ramifications are chiefly due to branches being given off laterally, and these never anastomose. The ramifications of the air-tubes within the lungs are called the *bronchial tubes*, and their ultimate subdivisions within the lobules are known as the *bronchioles*. Each bronchiole transmits air to and from a group of infundibula, or ultimate lobules.

Each lobular bronchial tube, after entering a lobule, divides into as many bronchioles as there are groups of infundibula or ultimate lobules. Each bronchiole, on approaching a cluster of, say, two or three infundibula, presents a dilatation, called the *vestibule*, and from this vestibule reception-chambers, known as the *atria*, proceed to the infundibula.

An **infundibulum** or **ultimate lobule** is an irregular, funnel-shaped passage, closed at one end, and having its walls and closed extremity beset with **air-cells** or **pulmonary alveoli,** which also beset, though more sparsely, the walls of the atria.

The bronchial tubes within the lungs are destitute of membranous walls posteriorly, and are cylindrical. This is due to the fact that their irregular plates of cartilage are disposed round the circumference of the wall. The muscular fibres are arranged in complete rings round the tubes, and the elastic tissue forms longitudinal bundles. The mucous membrane is freely provided with racemose mucous glands, and is covered with stratified ciliated columnar epithelium. When the tubes, by division, have attained a diameter of about $\frac{1}{25}$ inch, the cartilaginous plates disappear, and the walls consist of a fibro-elastic membrane and circularly-disposed muscular fibres, with a thin mucous coat, destitute of mucous glands, and covered with simple ciliated columnar epithelium, there being here and there patches of squamous, non-ciliated cells. The walls of the vestibule, atria, and air-cells are very thin and consist of areolar, elastic, and muscular tissues, the elastic element being specially developed at the margins of the orifices of the cells. This elastic

tissue enables the cells to recoil after distension. The interior of the vestibule, atria, and air-cells is lined with a single layer of squamous, non-ciliated

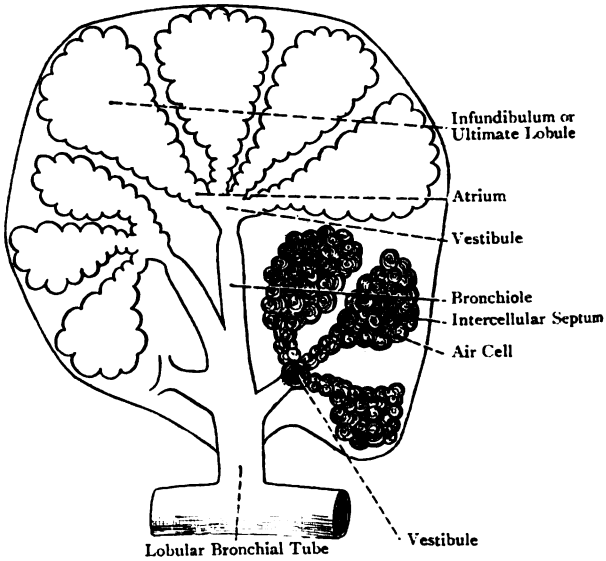


FIG. 377.—SCHEME OF A PULMONARY LOBULE (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

epithelium, which is of extreme delicacy in the air-cells. Upon the outer walls of the cells there are dense networks of capillary bloodvessels, which also pervade the septa between the cells, these septa being formed by infoldings of the contiguous cell-walls. Each septum contains only one capillary layer. The venous blood is thus brought into the most intimate relation with the air, all that separates the two being the very thin walls of the cells and the very delicate walls of the capillary bloodvessels. Moreover, there being only one capillary layer in each intercellular septum, the blood in the septal capillaries is exposed to the air on each side.

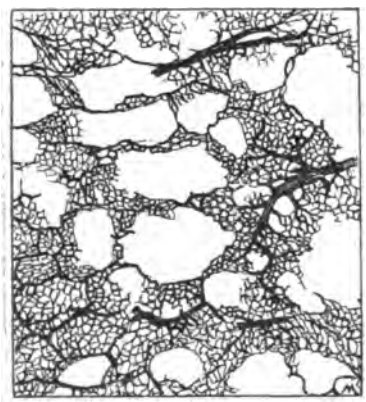


FIG. 378.—SECTION OF LUNG (INJECTED).

Summary of the Structure of the Lung.—The lung consists of an immense number of lobules, irregularly polygonal in outline, and each of these is provided with its own bronchial tube. A lobule is composed of groups of infundibula or ultimate lobules, and the lobular bronchial tube, on entering the lobule, divides into as many bronchioles as there are groups of infundibula. Each bronchiole, on approaching a cluster of infundibula, presents a dilatation, called the vestibule, from which atria lead to the infundibula.

The walls of the infundibula are freely beset with air-cells, which are also present, though more sparsely, on the walls of the atria. Upon the walls of the air-cells are dense networks of capillary bloodvessels, and each intercellular septum contains a single capillary layer.

Bloodvessels of the Lungs.—Two sets of arteries are associated with each lung, namely, pulmonary and bronchial, the former having to do with the respiratory function of the organ, and the latter with the nutrition of its component tissues. The **pulmonary arteries** are two in number, right and left. They result from the bifurcation of the pulmonary trunk, and convey venous blood to the lungs. Each artery ramifies freely within the lung, its branches accompanying the bronchial tubes, but they never anastomose with one another. Ultimately they terminate in dense capillary networks which lie upon the walls of the air-cells, and also in the septa between adjacent cells.

The **pulmonary veins** commence as radicles in the capillary networks already referred to, and they pass to the root of each lung, where they give rise to two pulmonary veins, which proceed to the left auricle of the heart and convey to it arterial or oxygenated blood. The pulmonary veins and their tributaries are destitute of valves. It is to be noted that the pulmonary arteries carry *venous* blood, whilst the pulmonary veins carry *arterial* blood.

The **bronchial arteries** convey arterial blood to the lungs for the nutrition of their component tissues. They will be described in connection with the descending thoracic aorta, with which they are associated.

The **bronchial veins** return their blood chiefly into the right azygos and upper left azygos veins respectively.

Lymphatics.—These are arranged in three sets, namely, superficial, deep or alveolar, and bronchial.

The *superficial lymphatics* are in communication with the copious subpleural lymphatic plexus on the surface of the lung. The *deep* or *alveolar lymphatics* proceed from the walls of the air-cells and from the intercellular septa. The *bronchial lymphatics* originate in the mucous membrane of the bronchial tubes. At the root of each lung the lymphatic vessels enter the bronchial glands.

Nerves.—These are derived from the anterior and posterior pulmonary plexuses, which are formed by the pneumogastric nerves, aided by branches from the sympathetic. The nerves penetrate as far as the air-cells, upon the walls of which they are regarded as terminating in arborizations. The anterior and posterior pulmonary plexuses will be found described on p. 910.

Development of the Respiratory Apparatus.—The earliest indication of the larynx, trachea, bronchial tubes, and lungs is a deep, median, vertical groove, called the *respiratory groove*, which is situated within the horseshoe elevation known as the *furcula*. It may be here stated that the loop or bend of the furcula gives rise to the epiglottis, its lateral limbs to the aryteno-epiglottidean folds, and their posterior extremities to the arytenoid cartilages. The surroundings of the respiratory groove thus represent the superior aperture of the larynx. The next stage consists in the deepening

of the respiratory groove, so as to form an elongated, vertical, *respiratory diverticulum* of the fore-gut, which communicates freely with it, and consists of hypoblast internally and mesoblast externally. The hypoblast gives origin to the respiratory epithelium, which is therefore continuous with the hypoblast of the fore-gut, and the mesoblast gives origin to the respiratory connective-tissue elements.

The median respiratory diverticulum next becomes separated from the fore-gut, which lies behind it. The separation takes place from below upwards, but in such a manner as to leave a small communication between the two at their upper or cephalic ends, which represents the rudimentary glottis. In this manner two tubes result, namely, posterior or œsophageal and anterior or laryngo-tracheal. The lower end of the respiratory diverticulum divides into two *lung-buds*, right and left, which grow into a collection of mesoblast. These buds represent the right and left bronchi and corresponding lungs. Their hypoblast gives rise to the epithelium, and the mesoblast into which they extend gives rise to the connective-tissue elements.

Each lung-bud subdivides, the right into three processes, and the left into two, thus indicating the three-lobed condition of the right lung and the two-lobed condition of the left. These processes in turn subdivide, and thus represent the ramifications of the bronchial tubes. The terminal parts of the minute ramifications give rise to the infundibula, and the air-cells are formed as diverticula from these infundibula and from the tubes immediately connected with them.

Lungs of the Fœtus.—The lungs prior to birth, having been impervious to air, feel solid, like liver, and they would at once sink if placed in a vessel containing water.

Innominate Veins.—These vessels are two in number, right and left, and each is formed by the junction of the internal jugular and subclavian veins behind the inner end of the clavicle. They both lie in the superior mediastinum.

The **right innominate vein** is about an inch in length, and passes downwards with a slight inclination inwards. At the level of the lower border of the first right costal cartilage, close to the sternum, it unites with the left innominate vein to form the superior vena cava. Externally it is closely related to the right phrenic nerve and right pleura; its internal relation is the upper part of the innominate artery; and, behind it, is the right pneumogastric nerve.

The **left innominate vein** is about 3 inches in length, and passes obliquely inwards and downwards from left to right. As stated, it joins its fellow of the right side to form the superior vena cava. In front of it there are the upper part of the manubrium sterni, the origins of the sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus body. Behind it are the origins of the innominate, left common carotid, and left subclavian arteries, the left pneumogastric and left phrenic nerves, and two superficial cardiac nerves from the cervical portions of the left pneumogastric and left sympathetic. Below it there is the arch of the aorta.

There are no valves in the innominate veins.

Tributaries. — Each vein receives the following tributaries: (1) the vertebral vein; (2) the inferior thyroid vein; (3) the internal mammary vein; and (4) the first intercostal vein. The last named

vessel, however, sometimes opens into the vertebral vein, and occasionally the right inferior thyroid vein opens into the left innominate vein. The *left* innominate vein receives, as an additional tributary, the left superior intercostal vein.

Development.—The *right* innominate vein is developed from that portion of the right primitive jugular vein which lies between the point where it receives the right subclavian and right internal jugular veins and the point where it is joined by the transverse jugular vein. The greater part (almost the whole) of the *left* innominate vein is developed from the transverse jugular vein.

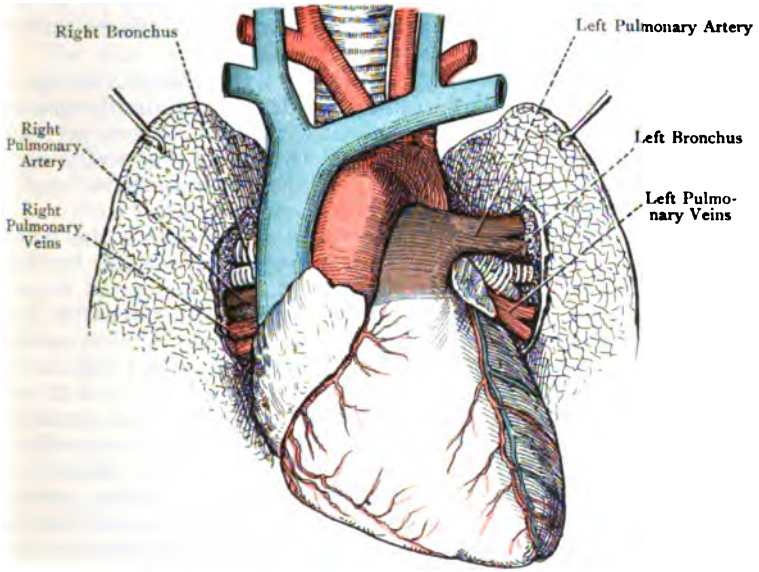


FIG. 379.—THE ROOTS OF THE LUNGS (ANTERIOR VIEW).

Superior Vena Cava. — This vessel is formed by the union of the right and left innominate veins behind the lower border of the first right costal cartilage, close to the sternum. It is about 3 inches in length, and descends almost vertically to the level of the upper border of the third right costal cartilage, where it opens into the postero-superior angle of the right auricle of the heart. In its course it pierces the fibrous portion of the pericardium. The upper half of the vessel is extrapericardial, and lies in the superior mediastinum; but the lower half is intrapericardial, and lies in the middle mediastinum.

Relations — Upper Half — *External.*— The right phrenic nerve and the right pleura. *Internal.*—The lower part of the innominate artery. **Lower Half**—*Internal.*—The ascending aorta. *Posterior.*—The root of the right lung. The serous portion of the pericardium

covers the lower part of the vessel except over about its posterior fourth.

The superior vena cava is destitute of valves.

Tributaries.—The chief tributary is the right azygos vein, after it has arched forwards over the right bronchus. It opens into the superior vena cava immediately before that vessel pierces the fibrous portion of the pericardium. Other minute tributaries are pericardial and mediastinal veins.

Development.—The portion of the superior vena cava *above* the right azygos vein is developed from that part of the right primitive jugular vein which lies below the point where it is joined by the transverse jugular vein; and the portion *below* the right azygos vein is developed from the right duct of Cuvier.

Inferior Vena Cava.—This vessel enters the thorax through the foramen quadratum in the central tendon of the diaphragm, and immediately thereafter it is received within the fibrous portion of the pericardium. Its course in the thorax is practically nil, as it may be said to open at once into the postero-inferior angle of the right auricle of the heart.

Thoracic Aorta.—The thoracic aorta extends from the base of the left ventricle of the heart to the level of the lower border of the body of the twelfth thoracic vertebra. At this point it passes through the aortic opening of the diaphragm, and thereafter enters upon the abdominal part of its course. It passes at first upwards and to the right; thereafter it sweeps, in an arched manner, upwards, backwards, and to the left, over the root of the left lung; and finally it descends in close contact with the vertebral column, lying at first upon its left side, but subsequently in front of it. It is therefore conveniently divided into three parts, namely, the ascending aorta, the arch of the aorta, and the descending aorta.

Ascending Aorta.—The ascending aorta commences at the base of the left ventricle of the heart, behind the left border of the sternum, on a level with the lower margin of the third left costal cartilage, and it terminates at a point behind the right border of the sternum on a level with the upper margin of the second right costal cartilage. Its course is upwards and to the right, with an inclination forwards. It lies in the middle mediastinum, and within the fibrous pericardium, which ensheathes it, and, for about the first 1½ inches of its course it is enclosed, along with the adjacent portion of the pulmonary artery, in a sheath formed by the serous part of the pericardium. The ascending aorta measures about 2 inches in length. At its commencement it presents three bulgings, which correspond to the sinuses of Valsalva in the interior and lie opposite the segments of the aortic valve. The bulgings are disposed as right antero-lateral, left antero-lateral, and posterior respectively. Along the right side of the vessel there is another somewhat extensive dilatation, called the *great sinus of the aorta.*

Relations—*Anterior.*—The root of the pulmonary artery and the right auricular appendix, at first, and subsequently the first piece

of the body of the sternum, from which it is separated by the pericardium, right pleura, and anterior margin of the right lung. *Posterior.*—The right pulmonary artery and the left auricle. *Right.*—The superior vena cava, and the right auricle. *Left.*—The trunk of the pulmonary artery.

Branches.—These are the two coronary arteries, right and left.

The **right coronary artery** arises from the right antero-lateral sinus of Valsalva. Passing forwards between the right auricular appendix and the root of the pulmonary artery, it enters the right auriculo-ventricular groove, which it traverses from front to back as far as the commencement of the inferior interventricular groove. At this point it divides into two branches, transverse and descending. The *transverse branch* enters the posterior part of the left auriculo-ventricular groove, in which it anastomoses with the transverse branch of the left coronary artery. The *descending branch* traverses the inferior interventricular groove as far as the region of the apex, where it anastomoses with the descending branch of the left coronary artery.

The right coronary artery furnishes branches to the right auricle and to both ventricles. One, of large size, called the *right marginal branch*, passes along the right border, or margo acutus, towards the apex.

The **left coronary artery** arises from the left antero-lateral sinus of Valsalva, and is at first concealed by the root of the pulmonary artery. It then passes forwards between the pulmonary artery and the left auricular appendix, and divides into two branches, transverse and descending. The *transverse branch* enters the left auriculo-ventricular groove, which it traverses from front to back, anastomosing posteriorly with the transverse branch of the right coronary artery. The *descending branch* traverses the antero-superior interventricular groove as far as the region of the apex, where it anastomoses with the descending branch of the right coronary artery.

The left coronary artery furnishes branches to the left auricle and to both ventricles. One, of large size, called the *left marginal branch*, springs from its transverse branch and passes along the left border, or margo obtusus, towards the apex.

Development.—The ascending aorta, along with the trunk of the pulmonary artery, is developed from the **aortic bulb.**

Arch of the Aorta.—The arch of the aorta commences behind the right border of the sternum, on a level with the upper margin of the second right costal cartilage, and it terminates on the left side of the body of the fourth thoracic vertebra, at the lower border of which it becomes the descending aorta. It passes upwards, backwards, and to the left, sweeping over the root of the left lung, and, when it reaches the left side of the body of the fourth thoracic vertebra, it descends. The height to which the arch reaches corresponds to the centre of the manubrium sterni, which is about

1 inch below the upper border of the manubrium. It lies in the superior mediastinum, and its left side is in close relation with the left pleura.

Relations—*Anterior.*—The left phrenic and left pneumogastric

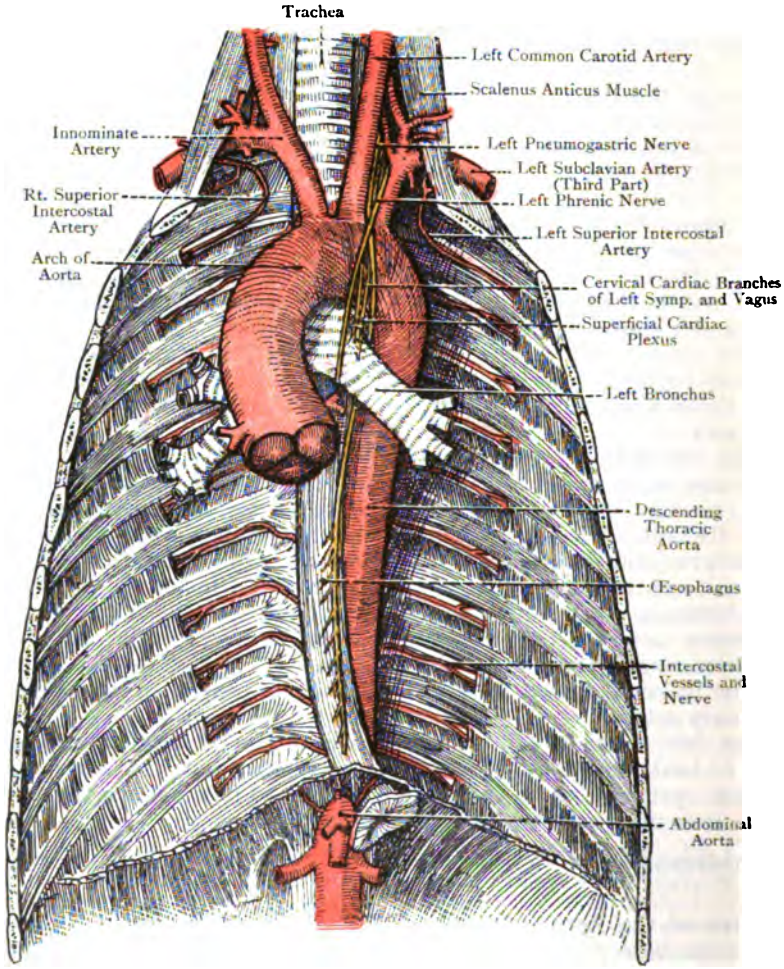


FIG. 380.—DISSECTION OF THE POSTERIOR WALL OF THE THORAX.

nerves, the former being on the right side of, and anterior to, the latter. Between these two nerves are the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, both on their way to the super-

ficial cardiac plexus, which they form. All these nerves are overlaid by the left pleura. Farther back than these nerves is the left superior intercostal vein. The remains of the thymus body constitute an additional anterior relation. *Posterior.*—The trachea, deep cardiac plexus of nerves, œsophagus, thoracic duct, and left recurrent laryngeal nerve. *Superior.*—The left innominate vein, and the origins of the following three great arteries, named in order from right to left, and also from before backwards: the innominate, the left common carotid, and the left subclavian. *Inferior.*—The left bronchus, the bifurcation of the pulmonary artery, the superficial cardiac plexus of nerves, the left recurrent laryngeal nerve, and the ligamentum ductûs arteriosi. The last-named fibrous cord is attached to the back part of the concavity of the arch, immediately beyond the level of the origin of the left subclavian artery.

The arch presents a constriction immediately beyond the origin of the left subclavian artery, called the *aortic isthmus*, and this is succeeded by a short fusiform dilatation, known as the *aortic spindle of His*. These conditions are best marked in the fœtus.

Branches.—These are three in number, namely, the innominate, left common carotid, and left subclavian arteries. They arise in the order named, proceeding from before backwards, and also from right to left.

Innominate Artery.—This vessel is the first and largest of the three branches which arise from the arch of the aorta. It springs from the upper aspect of the arch rather above the level of the upper border of the second right costal cartilage, and it terminates behind the upper border of the right sterno-clavicular joint by dividing into the right common carotid and right subclavian arteries. It is from 1½ to 2 inches in length, its direction is upwards and outwards, and it lies in the superior mediastinum.

Relations—*Anterior.*—The right half of the manubrium sterni, with the origins of the right sterno-hyoid and sterno-thyroid muscles; the left innominate and the right inferior thyroid veins; the right sterno-clavicular joint; and some remains of the thymus body. *Posterior.*—The trachea at first, but, as the artery ascends obliquely to the right, it leaves the front of the trachea and is placed on its right side. The three cervical cardiac branches of the right sympathetic also lie behind the artery on their way to the deep cardiac plexus. *Right.*—The right pleura; the innominate vein, with the right pneumogastric nerve behind it; the superior vena cava; and the right phrenic nerve. *Left.*—The left common carotid artery, and the trachea, in this order from below upwards.

Branches.—These are terminal, and are two in number, namely, the right common carotid and the right subclavian. The artery, as a rule, gives off no branches in its course. Occasionally, however, it gives origin to a vessel, of variable size, called the *arteria thyroidea ima* (lowest thyroid artery). The interest attached to this occasional branch is that, in ascending to the isthmus of the

thyroid body in the neck, it lies in front of the trachea, and would be endangered in performing the low operation of tracheotomy.

Varieties.—(1) The innominate artery may be shorter or longer than usual. (2) In cases of high bifurcation the artery may so encroach upon the trachea as endangered in performing the low operation of tracheotomy.

Left Common Carotid Artery in the Thorax.—This vessel arises from the upper aspect of the arch of the aorta, just to the left of, and posterior to, the origin of the innominate artery. It lies in the superior mediastinum, and its direction is upwards and to the left. Having reached the posterior aspect of the left sterno-clavicular joint, it enters upon the cervical part of its course.

Relations—*Anterior.*—The left half of the manubrium sterni, with the origins of the left sterno-hyoid and sterno-thyroid muscles, but these structures lie at a little distance from the vessel; the left innominate vein; and some remains of the thymus body. *Posterior.*—The trachea at first, and subsequently the œsophagus (which here deviates slightly to the left of the trachea), and the thoracic duct. *Right.*—The innominate artery at first, and thereafter the trachea. *Left.*—The left pneumogastric and left phrenic nerves, with the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric; and the left pleura and lung.

The thoracic portion of the left subclavian artery is on the left of, and posterior to, the vessel, but at a little distance from it.

The thoracic portion of the left common carotid artery gives off no branches.

First Part of the Left Subclavian Artery in the Thorax.—This vessel arises from the upper aspect of the arch of the aorta, a little to the left of, and posterior to, the origin of the left common carotid artery. It lies deeply in the superior mediastinum, and is almost parallel to the thoracic portion of the left common carotid, its course being nearly vertical.

Relations—*Anterior.*—The left common carotid artery; the left pneumogastric and left phrenic nerves, with the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, all these nerves lying between it and the left common carotid artery; and the left innominate vein. *Posterior.*—The œsophagus, and the thoracic duct. *Right.*—The trachea, and the left recurrent laryngeal nerve. *Left.*—The left pleura, and the inner aspect of the left lung, the latter being grooved by the vessel.

The thoracic portion of the left subclavian artery gives off no branches.

Varieties of the Aorta—1. **Position.**—(*a*) The arch of the aorta may rise as high as the upper border of the manubrium sterni, or it may stop short of the level of the centre of the manubrium. (*b*) It may be a right aortic arch, instead of a left, in which cases there may, or may not, be a transposition of the viscera. The presence of a right aortic arch is due to its formation from the fourth right arterial arch, and the persistence of the right primitive dorsal aorta.

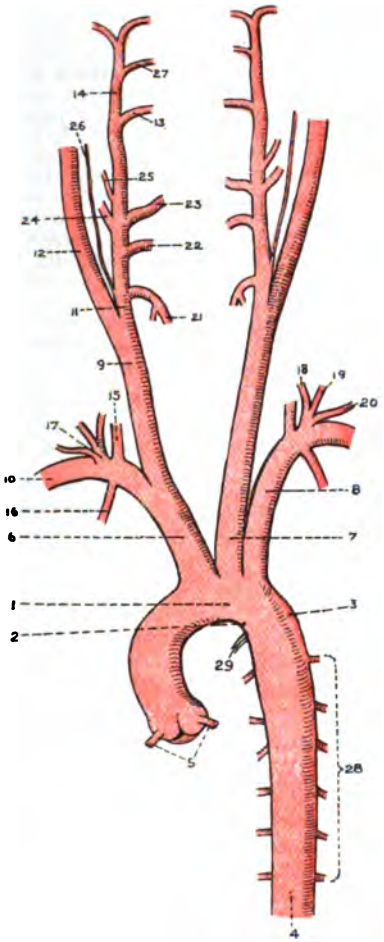


FIG. 381.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Internal Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyroid Axis
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Aortic Intercostals
29. Lig. Ductûs Arteriosi

2. **Branches of the Arch and their Positions.**—Varieties in these respects are very numerous. The normal number of branches arising from the arch is three. There may, however, be four. The most common additional branch is the **left vertebral artery,** its place of origin being between the left common carotid and left subclavian arteries. The right vertebral artery sometimes arises from the arch, but this is somewhat rare. An **arteria thyroidea ima** may arise from the arch between the innominate and left common carotid arteries. In rare cases the **internal mammary artery,** or the **inferior thyroid,** may spring from the arch. The innominate artery may be absent, in which cases the right subclavian and right common carotid have independent origins. Under these circumstances the **right subclavian artery** may be the last of the branches from the upper part of the arch, and, when this is so, in order to reach the right side of the neck, it crosses in front of the vertebral column, lying behind the œsophagus, or between the trachea and the œsophagus.

Development of the Arch of the Aorta and its Branches.—As already stated, the **ascending aorta** is developed, along with the **pulmonary artery,** from the *aortic bulb*. The **arch of the aorta** is developed chiefly from the *fourth left arterial arch*, but slightly also from the *root of the left primitive ventral aorta*, that is, the part as high as the fourth left arterial arch.

The **innominate artery** is developed from the *root of the right primitive ventral aorta*—that is, the part as high as the fourth right arterial arch.

The **left common carotid artery** is developed from *that portion of the left primitive ventral aorta which lies between the fourth and third left arterial arches.*

The **left subclavian artery** is developed from a segmental artery.

For the description of the **descending aorta,** see p. 949.

Pulmonary Artery.—This is the great vessel which, by means of its right and left divisions, carries the venous blood from the right ventricle of the heart to the lungs. It is therefore an example of an artery which conveys venous blood, and in this respect resembles the hypogastric and umbilical arteries of the fœtus. It arises from the infundibulum, or conus arteriosus, of the right ventricle of the heart, on a level with the upper margin of the third left costal cartilage at its junction with the sternum. It is directed upwards and backwards, and, after a course of about 2 inches, breaks up into two divisions, right and left, within the concavity of the arch of the aorta. The vessel lies in the middle mediastinum, and, along with the ascending aorta, it is contained within the pericardium, the serous portion of which forms one common sheath for the two arteries over about the first 1½ inches of their course.

Relations—*Anterior.*—The sternal extremity of the second left intercostal space and second left costal cartilage; and the left pleura and left lung. *Posterior.*—The root of the ascending aorta; the commencement of the left coronary artery; and the left auricle of the heart. *Right.*—The right coronary artery; the right auricular appendix; and the ascending aorta. *Left.*—The left coronary artery; and the left auricular appendix.

The only **branches** of the artery are the two terminal divisions.

The **right pulmonary artery** passes outwards to the right, behind the ascending aorta and superior vena cava, to the root of the right lung, where it divides into two branches, upper and lower. The upper branch is distributed to the upper lobe, and the lower branch, which is the larger of the two, is distributed to the middle and lower lobes.

The **left pulmonary artery** passes outwards to the left, in front of the left bronchus and descending aorta, to the root of the left lung, where it divides into two branches, one for the upper, and the other for the lower, lobe. The ligamentum ductûs arteriosi is attached to the upper aspect of its root.

The *right* pulmonary artery is larger and longer than the left.

Development.—The **trunk of the pulmonary artery**, along with the ascending aorta, is chiefly developed from the *aortic bulb*, but a small portion of it is formed by the *commencement of the sixth left arterial arch*, which remains connected with that portion of the aortic bulb which becomes partitioned off to form the pulmonary trunk.

The **right** and **left pulmonary arteries** are developed as branches from the *sixth left arterial arch near its commencement*, the remainder of that arch giving rise to the ductus arteriosus of the fœtus.

Ligamentum Ductûs Arteriosi.—This is a fibrous cord which is the remains of an important vessel, peculiar to fœtal life, called the *ductus arteriosus*. It extends from the upper aspect of the root of the left pulmonary artery to the under surface of the arch of the aorta, immediately beyond the level of the origin of the left subclavian artery. Its direction is upwards, backwards, and slightly to the left.

During fœtal life the right and left pulmonary arteries are of small size, and the ductus arteriosus conveys the greater part of the venous blood from the right ventricle of the heart into the aorta at a point *beyond* the origin of the left subclavian artery. None of this blood, therefore, can pass into the great vessels which spring from the upper aspect of the arch of the aorta.

Pulmonary Veins.—These vessels carry the arterial or oxygenated blood from the lungs to the left auricle of the heart. Though they are called veins, they contain arterial blood, and in this respect resemble the umbilical vein of the fœtus. They are four in number, two right and two left, and, at the root of each lung, the upper of the two is on a more anterior plane than the lower. The *right veins* pass behind the superior vena cava and the right auricle, and the *left veins* pass in front of the descending aorta. All four vessels open into the left auricle on its posterior aspect. On leaving the roots of the lungs the veins are said to receive small bronchial tributaries from the adjacent bronchial tubes and glands.

The *right* pulmonary veins are larger and longer than those of the left side.

Pneumogastric Nerves in the Thorax.—These nerves, right and left, differ so much from each other in their course and relations as to require separate descriptions.

The **right pneumogastric,** or **vagus, nerve,** having descended in front of the first part of the right subclavian artery, and having given off its inferior or recurrent laryngeal branch at the lower border of that vessel, enters the thoracic cavity. It then descends in the superior mediastinum behind the innominate vein, and, inclining backwards, it reaches the right side of the trachea, along which it courses to the *posterior aspect* of the root of the right lung. Behind the root of the right lung the nerve becomes flattened out

and breaks up into numerous branches, which are disposed in a plexiform manner, and constitute the *right posterior pulmonary plexus*, from which branches are given off to the right lung. From the lower part of this plexus the nerve issues in the form of two cords, which descend in the posterior mediastinum upon the right side of the œsophagus, or gullet, and communicate freely with the corresponding cords of the left side. In this manner a plexus is formed, which is called the *plexus gulæ*. Subsequently the two cords of the right side unite to form a single nerve, which descends on the *posterior surface* of the œsophagus, and enters the abdomen through the œsophageal opening of the diaphragm to be distributed to the *posterior surface* of the stomach.

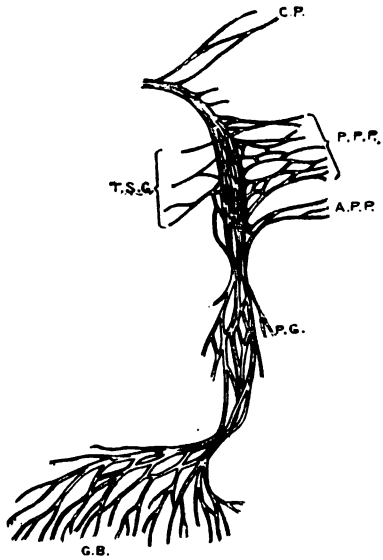


FIG. 382.—SCHEME OF PNEUMOGASTRIC NERVE IN THORAX AND ABDOMEN (FLOWER).

C.P. Branches to Cardiac Plexus
P.P.P. Branches to Posterior Pulmonary Plexus
A.P.P. Branches to Anterior Pulmonary Plexus
T.S.G. Branches from Upper Thoracic Ganglia of Sympathetic
P.G. Plexus Gulæ
G.B. Gastric Branches

The **left pneumogastric, or vagus, nerve** enters the thoracic cavity between the left common carotid and left subclavian arteries, and descends in the superior mediastinum behind the left innominate vein. It then passes in front of the arch of the aorta, having the left phrenic nerve on its right side and anterior to it, with the intervention of the superior cervical cardiac branch of the left sympathetic and its own inferior cervical cardiac branch. At the lower border of the arch it gives off its inferior or recurrent laryngeal branch, and then passes to the *posterior aspect* of the root of the left lung. Behind the root of the left lung the nerve, as on the right side, becomes flattened out and breaks up into numerous branches, which are disposed in a plexiform manner, and constitute the *left posterior pulmonary plexus*, from which branches are given off to the left lung. From the lower part of this plexus the nerve, as on the right side, issues in the form of two cords, which descend in the posterior mediastinum upon the left side of the œsophagus or gullet, and communicate freely with the corresponding cords of the right side. In this manner, as stated, a plexus is formed, which is called the *plexus gulæ*. Subsequently the two cords of the left side unite to form a single nerve, which descends on the *anterior*

surface of the œsophagus, and enters the abdomen through the œsophageal opening of the diaphragm, to be distributed to the *anterior surface* of the stomach.

Differences between the Right and Left Pneumogastric Nerves.

Right Pneumogastric Nerve.	Left Pneumogastric Nerve.
1. Descends in front of first part of right subclavian artery.	1. Descends between left common carotid and left subclavian arteries.
2. Gives off its recurrent laryngeal branch at lower border of right subclavian artery.	2. Passes behind left innominate vein.
3. Lies behind right innominate vein.	3. Crosses in front of arch of aorta.
4. Lies on right side of trachea.	4. Gives off its recurrent laryngeal branch at lower border of arch.
5. Lies at first on right side of œsophagus, and then behind it.	5. Lies at first on left side of œsophagus, and then in front of it.
6. Ramifies on posterior surface of stomach.	6. Ramifies on anterior surface of stomach.

Branches.—These are as follows: the left inferior or recurrent laryngeal; cardiac, from the right nerve; pulmonary; œsophageal; and pericardial.

The *left inferior* or *recurrent laryngeal nerve* arises from the left pneumogastric in front of the arch of the aorta, on a level with its lower border. It passes backwards within the arch at the place of attachment of the ligamentum ductûs arteriosi, and then it turns upwards behind the arch. Having reached the groove between the trachea and the œsophagus, it ascends therein to the neck, where its subsequent course and distribution will be described. In the thorax the nerve, which contains fibres derived from the bulbar or accessory portion of the spinal accessory nerve, furnishes a few cardiac branches to the deep cardiac plexus as it winds round the arch of the aorta.

The right inferior or recurrent laryngeal nerve is extra-thoracic, inasmuch as it arises from the right pneumogastric at the root of the neck, and it winds round the first part of the right subclavian artery.

The recurrent course of the right and left recurrent laryngeal nerves is brought about by the change in position which the heart and great vessels undergo in the course of development. In early embryonic life each recurrent laryngeal nerve passes inwards to the larynx below the corresponding sixth arterial arch. This arch on the right side, together with the fifth, disappears, and the right recurrent laryngeal nerve then becomes related to the fourth right arterial arch, from which the first part of the right subclavian artery is developed. The sixth left arterial arch gives rise to the ductus arteriosus, which, however, becomes obliterated, and then the left recurrent laryngeal nerve becomes related to the fourth left arterial arch (the fifth having disappeared) at the place where it receives the ductus arteriosus, and from this fourth left arch the arch of the aorta is developed. As the heart and great vessels descend from the neck into the thorax each recurrent laryngeal

nerve is necessarily drawn downwards, and the right nerve becomes recurrent round the first part of the right subclavian artery (the original fourth right arterial arch), whilst the left nerve becomes recurrent round the arch of the aorta (the original fourth left arterial arch) at the place of attachment of the ligamentum ductûs arteriosi.

The *cardiac branches* of the **right** pneumogastric are two or three in number, and they descend upon the trachea to the deep cardiac plexus. (The cardiac branches on the left side are derived, as stated, from the left recurrent laryngeal nerve as it winds round the arch of the aorta).

The *pulmonary branches* are arranged in two sets, anterior and posterior. The *anterior pulmonary branches* are two or three in number, and arise from the parent trunk before it disappears behind the root of the lung. They pass to the anterior aspect of the root, and, being joined by sympathetic twigs, they form the **anterior pulmonary plexus,** which is reinforced by twigs from the deep cardiac plexus, and, in the case of the left anterior pulmonary plexus, by twigs from the superficial cardiac plexus. The branches of the anterior pulmonary plexus enter the lung, and accompany the ramifications of the bronchial tubes.

The *posterior pulmonary branches* arise from the pneumogastric nerve behind the root of the lung. They are larger and more numerous than the anterior branches, and, being joined by twigs from the second, third, and fourth thoracic sympathetic ganglia, they form the **posterior pulmonary plexus.** The branches of this plexus, like those of the anterior, enter the lung, and accompany the ramifications of the bronchial tubes.

The *œsophageal branches* arise chiefly from the plexus gulæ, below the level of the roots of the lungs, and they are distributed to the portion of the œsophagus which occupies the posterior mediastinum. Other œsophageal branches, however, arise above the level of the roots of the lungs, and are distributed to the portion of the œsophagus which occupies the superior mediastinum.

The *pericardial branches* arise from the plexus gulæ, and are distributed to the pericardium, which they enter from behind.

Summary of Branches.

Right Pneumogastric Nerve.	**Left Pneumogastric Nerve.**
Cardiac.	Recurrent Laryngeal (which gives off Cardiac branches).
Anterior Pulmonary.	Anterior Pulmonary.
Posterior Pulmonary.	Posterior Pulmonary.
Œsophageal.	Œsophageal.
Pericardial.	Pericardial.

Cardiac Plexus.—The cardiac plexus is one of three large prevertebral plexuses associated with the sympathetic system, the other two, namely, the epigastric or solar and the hypogastric, being situated in the abdominal cavity. The plexus is situated partly in the concavity of the arch of the aorta, and partly upon

the trachea above the bifurcation and behind the aortic arch. It is formed by branches of the pneumogastric and sympathetic nerves, and consists of two portions, superficial and deep, which communicate with each other.

The **superficial cardiac plexus,** which is comparatively small, is situated in the concavity of the arch of the aorta, between the ligamentum ductûs arteriosi and the right pulmonary artery. It is formed by (1) the superior cervical cardiac branch of the *left* sympathetic, and (2) the inferior cervical cardiac branch of the left pneumogastric, nerves. These two nerves descend over the arch of the aorta, lying between the left phrenic and left pneumogastric nerves. At the place where the two nerves join there may be a small ganglion, which is known as the *ganglion of Wrisberg.*

Branches.—The plexus gives branches to the left anterior pulmonary plexus, and, having received a considerable accession of fibres from the right half of the deep cardiac plexus, it is prolonged into the *right* coronary plexus.

The **deep cardiac plexus,** of larger size than the superficial, is situated upon the trachea immediately above the bifurcation and behind the arch of the aorta. It is formed by (1) all the **cervical** cardiac branches of the *right* sympathetic, namely, superior, middle, and inferior, and of the *right* pneumogastric, namely, superior and inferior; (2) one or two cardiac branches from the *right* recurrent laryngeal nerve; (3) one or two **thoracic** cardiac branches from the *right* pneumogastric; (4) the middle and inferior cervical cardiac branches of the *left* sympathetic; (5) the superior cervical cardiac branch of the *left* pneumogastric; and (6) the thoracic cardiac branches of the *left* recurrent laryngeal nerve. It is arranged in two halves, right and left, which communicate with each other; the right half also gives a considerable accession of fibres to the superficial cardiac plexus. Each half receives the following branches:

Right Half.	Left Half.
1. The three cervical cardiac branches of the right sympathetic.	1. The middle and inferior cervical cardiac branches of the left sympathetic.
2. The two cervical cardiac branches of the right pneumogastric.	2. The superior cervical cardiac branch of the left pneumogastric.
3. The cardiac branches of the right recurrent laryngeal.	3. The cardiac branches of the left recurrent laryngeal.
4. The thoracic cardiac branches of the right pneumogastric.	

Branches.—The *right half* of the deep cardiac plexus gives off (1) branches to the right anterior pulmonary plexus; (2) branches to the right auricle of the heart; (3) branches to reinforce the right coronary plexus, which is derived, as stated, from the superficial cardiac plexus; and (4) a few branches to the left coronary plexus. The *left half* of the deep cardiac plexus gives off (1) branches to the

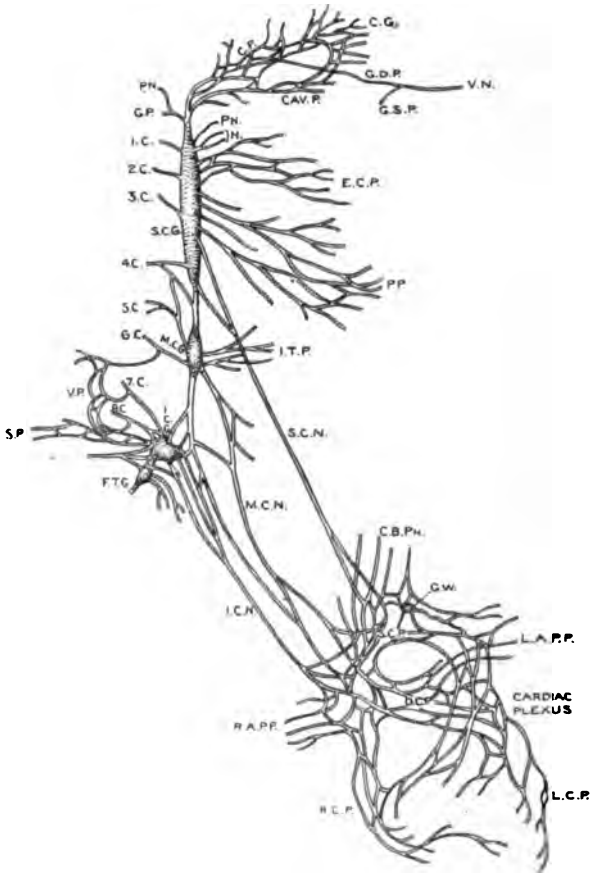


FIG. 383.—SCHEME OF THE SYMPATHETIC NERVE IN THE NECK, AND OF THE CARDIAC PLEXUS (FLOWER).

S.C.G. Superior Cervical Ganglion.

P.N. and G.P. Branches to Pneumogastric and Glosso-pharyngeal
1c, 2c, 3c, 4c. Branches to Upper Four Cervical Nerves
C.P. Carotid Plexus
Cav. P. Cavernous Plexus
C.G. Branch to Ciliary Ganglion
G.D.P. Great Deep Petrosal
G.S.P. Great Superficial Petrosal
V.N. Vidian Nerve
P.N. To Ganglion of Trunk of Pneumogastric
H. To Hypoglossal
E.C.P. To External Carotid Plexus
P.P. To Pharyngeal Plexus
S.C.N. Superior Cardiac Nerve

M.C.G. Middle Cervical Ganglion.

5c, 5c. To Fifth and Sixth Cervical Nerves
I.T.P. To Inferior Thyroid Plexus
M.C.N. Middle Cardiac Nerve

I.C.G. Inferior Cervical Ganglion.

7c, 8c. To Seventh and Eighth Cervical Nerves
V.P. To Vertebral Plexus
S.P. To Subclavian Plexus
I.C.N. Inferior Cardiac Nerve

F.T.G. First Thoracic Ganglion

Cardiac Plexus.

C.B.Pn. Cardiac Branches of Pneumogastric
S.C.P. Superficial Cardiac Plexus
G.W. Ganglion of Wrisberg
D.C.P. Deep Cardiac Plexus
R.A.P.P. Right Anterior Pulmonary Plexus
L.A.P.P. Left Anterior Pulmonary Plexus
R.C.P. Right Coronary Plexus
L.C.P. Left Coronary Plexus

left anterior pulmonary plexus ; (2) branches to the left auricle of the heart ; and (3) the left coronary plexus.

Coronary Plexuses.—These are two in number, right and left.

The **right coronary plexus** is formed by branches from (1) the superficial cardiac plexus, and (2) the right half of the deep cardiac plexus. It accompanies the right coronary artery, and furnishes branches to the right auricle and right ventricle of the heart.

The **left coronary plexus** is formed by branches which are derived chiefly from the left half of the deep cardiac plexus, but it also receives a few branches from the right half. It accompanies the left coronary artery, and furnishes branches to the left auricle and left ventricle of the heart.

Ganglia are met with in the coronary plexuses, and in the course of the fibres which supply the walls of the auricles. They are also present on the fibres which supply the walls of the ventricles in the region of the auriculo-ventricular groove, but nowhere else. In the heart of the calf the nerves are easily recognised beneath the visceral layer of the pericardium, as they pass across the muscular fibres in an oblique manner.

Heart.—The heart is a hollow, muscular organ, which, enclosed within the pericardium, is situated in the middle mediastinum, where it lies obliquely between the two lungs. It is conical in shape, and is free to move within its pericardial sac, except at the base, where it is connected with the great bloodvessels. Its relation to the thoracic wall, during life, is influenced by posture and by the respiratory movements. When a person lies upon the left side, or when the prone position is assumed, the organ is more intimately related to the thoracic wall than in the opposite postures ; and during inspiration it is less intimately connected with the thoracic wall than during expiration.

General Relations and Topography.—The heart lies obliquely behind the lower three-fourths of the body of the sternum. About two-thirds of the organ are contained in the left half of the thoracic cavity, and about one-third in the right half. The *base* is directed upwards, backwards, and to the right, and lies opposite the bodies of the middle four thoracic vertebræ, namely, the fifth, sixth, seventh, and eighth. The *apex* is directed downwards, forwards, and to the left, and, during life, it strikes the thoracic wall in the fifth left intercostal space, 1½ inches below the left nipple, and about ¾ inch within the left mammillary line. This point represents the apex-beat, and is about 3½ inches from the median line of the sternum. The *antero-superior surface*, which is convex, lies behind the lower three-fourths of the body of the sternum and the corresponding costal cartilages, right and left, namely, the third, fourth, fifth, and sixth, more particularly those of the left side. This surface is encroached upon by the pleuræ and the thin anterior margins of the lungs. Opposite the cardiac notch on the anterior margin of the left lung there is a small portion which is uncovered by lung, unless during deep inspiration, and this cor-

responds with the *area of precordial dulness*. **Latham's circle** is taken as defining this area, and the directions for describing the circle are as follows: 'Make a circle of 2 inches in diameter round a point midway between the left nipple and the end of the sternum.' Strictly speaking, the area of precordial dulness is triangular in conformity to the V-shaped cardiac notch on the anterior margin of the left lung, and it may be mapped out by the following lines: one drawn from the position of the apex-beat to the median line of the sternum on a level with the fourth left costal cartilage; another drawn from the position of the apex-beat to the median line of the sternum at the junction of the body and ensiform process; and a third connecting the mesial ends of these two lines, and extending along the middle of the sternum. The *inferior* or *diaphragmatic surface*, which is flat, is directed downwards, and rests upon the upper surface of the central tendon of the diaphragm, covered by the serous portion of the pericardium.

The outline of the heart, in reference to the anterior wall of the thorax, may be indicated, with approximate accuracy, in the following manner:

Base.—Draw a line across the sternum on a level with the upper border of the third right, and the lower border of the second left, costal cartilages, and prolong this line for ½ inch to the right of the sternum, and 1 inch to the left of it.

Inferior (Right) Border, or *Margo Acutus.*—Draw a line from the sternal end of the sixth right costal cartilage to the position of the apex-beat. This line corresponds to the lower limit of the heart.

Right Limit.—Draw a line from the upper border of the third right costal cartilage, ½ inch from the sternum, to the sternal end of the sixth right costal cartilage. This line should be curved outwards to such an extent that its greatest convexity will be 1½ inches distant from the median line of the sternum. It corresponds with the right limit of the right auricle.

Left Border, or *Margo Obtusus vel Rotundus.*—Draw a line from the lower border of the second left costal cartilage, 1 inch from the sternum, to the position of the apex-beat. This line should be slightly curved outwards, but it must not include the left nipple. It corresponds to the left limit of the heart.

Course of the Circulation.—The interior of the heart is divided by two septa (interauricular and interventricular) into two halves, right and left, and each half is subdivided by a transverse constriction into two chambers, an upper or auricle, and a lower or ventricle, right and left respectively. The auricles, except in the fœtus, are completely separated from each other by a septum, and so also are the ventricles; but the auricle and ventricle of each side communicate freely with each other by the auriculo-ventricular orifice. The right auricle receives the venous blood chiefly from the superior and inferior venæ cavæ and the coronary sinus. From the right auricle the blood passes into the right ventricle, and thence into the trunk of the pulmonary artery. The right and

left pulmonary arteries convey it to the lungs, and in passing through the pulmonary capillaries it is oxygenated and becomes arterial blood. It is then taken up by the pulmonary venous radicles, and conveyed to the pulmonary veins, which carry it to the left auricle of the heart. From the left auricle it passes into the left ventricle, whence it is driven into the aorta. The aorta and its various ramifications convey the arterial blood to the different parts of the body, and thereafter it is returned as venous blood to the right auricle of the heart.

Exterior of the Heart.—The exterior of the heart presents distinct indications of its division internally into four chambers.

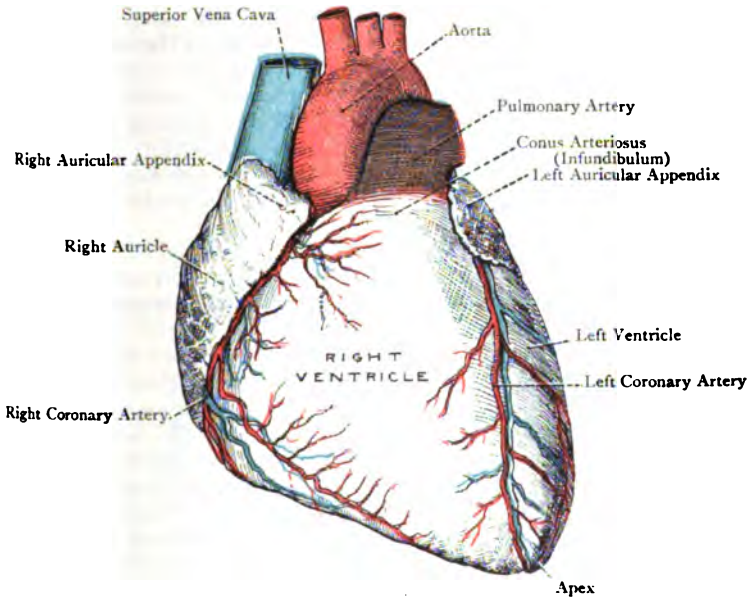


FIG. 384.—THE HEART (ANTERIOR VIEW).

These take the form of grooves, namely, auriculo-ventricular, interauricular, and interventricular.

The *auriculo-ventricular groove*, which is deep, divides the heart into auricular and ventricular portions, and it surrounds the organ except in front, where the roots of the aorta and pulmonary artery are situated. The auricular portion is posterior and superior in position, whilst the ventricular portion is anterior and inferior. The *right half* of the auriculo-ventricular groove contains (1) the right coronary artery, and (2) the right or small cardiac vein, which latter lies chiefly in its posterior part. The *left half* of the auriculo-ventricular groove contains (1) the transverse branch of the left coronary artery, (2) the transverse branch of the right coronary

artery, which lies in its posterior part ; (3) a portion of the great cardiac or coronary vein, which lies in its anterior part, and also slightly in its posterior part ; and (4) the coronary sinus, which lies in its posterior part.

The **auricular portion** of the heart has the form of a crescent, the horns of which represent the auricular appendices, and are directed forwards. The concavity of the crescent is also directed forwards, and it lodges the roots of the aorta and pulmonary artery, the latter being the more anterior of the two. The walls of the auricular portion are thin, and it is divided into two auricles, right and left. The external indication of this division is the *interauricular groove*, which is situated vertically on the posterior surface, to the left of the openings of the superior and inferior venæ cavæ. This groove corresponds to the posterior attachment of the interauricular septum in the interior. The greater part of the posterior surface of the auricular portion is formed by the left auricle. The large posterior part of each auricle is called the *atrium* ('reception-chamber'), and projecting forwards from the anterior and upper part of each atrium there is the *auricular appendix*. The two auricular appendices embrace between them the roots of the aorta and pulmonary artery.

The **right auricle** forms the anterior and right part of the base of the heart, and is quadrangular. The superior vena cava enters its atrium at the postero-superior angle, and the inferior vena cava at the postero-inferior angle. Near the latter vein the coronary sinus also opens into the atrium. The *right auricular appendix* is prolonged forwards from the antero-superior angle of the atrium. and inclines to the left in front of the root of the ascending aorta. It is shorter, broader, and less curved than the left auricular appendix, and its margin is notched, but not so much so as in the left appendix. The right auricle is traversed by a groove, called the *sulcus terminalis*, which extends from the front of the termination of the superior vena cava to the right side of the termination of the inferior vena cava. This groove indicates where the *saccus reuniens* of embryonic life meets the primitive auricle.

The **left auricle** forms the posterior and left part of the base of the heart. It is quadrilateral, and the greater part of it lies flattened behind the ascending aorta and trunk of the pulmonary artery. The pulmonary veins, two right and two left, open into the posterior part of its atrium. The *left auricular appendix* is prolonged forwards from its left aspect, and inclines to the right over the left side of the root of the pulmonary artery. It is longer, narrower, and more curved than the right auricular appendix, and its margin is more deeply notched. The back of the left auricle is related to the œsophagus, with the intervention of the pericardium, and the small *oblique vein of Marshall* passes downwards and inwards upon it, to open into the coronary sinus.

The **ventricular portion** of the heart is conical, its walls are thick, and it is divisible into two ventricles, right and left. The ex-

ternal indication of this division is the interventricular groove, which corresponds to the attachments of the interventricular septum in the interior. This groove consists of two parts, antero-superior and inferior. The *antero-superior interventricular groove* extends over the antero-superior surface of the heart from the left side of the root of the pulmonary artery to the inferior border, or margo acutus, to the right of, and near, the apex. At this point it becomes continuous with the inferior interventricular groove. It contains, besides fat, (1) the descending branch of the left coronary artery, and (2) a part of the great cardiac or coronary vein (more

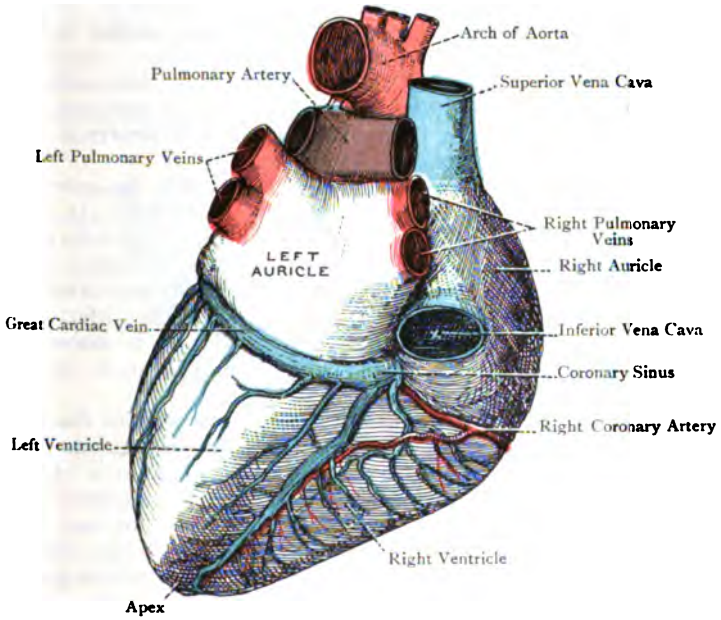


FIG. 385.—THE HEART (POSTERIOR VIEW).

properly called the antero-superior interventricular vein in this region). The *inferior interventricular groove* is situated on the inferior surface of the heart, and, as stated, is continuous with the preceding. It contains, besides fat, (1) the descending (inferior) branch of the right coronary artery, and (2) the middle cardiac vein (more properly called the inferior interventricular vein).

The ventricular portion of the heart presents an apex, a base, two surfaces, and two borders. The **apex** is directed downwards, forwards, and to the left, and forms the apex of the heart. The *left* ventricle alone enters into its formation. The **base** is directed upwards, backwards, and to the right, and is connected with the

atria of the auricles and the origins of the aorta and pulmonary artery, the former being behind, and the latter in front.

The **surfaces** are antero-superior and inferior. The *antero-superior surface* is convex, and is traversed by the antero-superior interventricular groove. As this groove lies near the left border, the greater part of this surface (about two-thirds) is formed by the right ventricle, and the remainder by the left ventricle. In *post-mortem* examinations, therefore, when the pericardium is opened, the **right** ventricle is chiefly exposed for inspection. On this aspect of the right ventricle there are the anterior cardiac veins. Its upper and left part is somewhat conical, and is called the *infundibulum* or *conus arteriosus*. It gives origin superiorly to the trunk of the pulmonary artery. The *inferior surface* is flat, and is traversed by the inferior interventricular groove. As this groove lies near the inferior border, the greater part of this surface (about two-thirds) is formed by the left ventricle, and the remainder by the right ventricle. On this aspect of the left ventricle there are the posterior cardiac veins.

The **borders** are inferior (right) and left. The *inferior border* is comparatively long, and extends from right to left. It is formed by the right ventricle, and is sharp in outline, from which circumstance it is known as the *margo acutus*. The marginal branch of the right coronary artery and one of the anterior cardiac veins lie along it. The *left border* is shorter than the inferior, and is blunt and round, from which circumstances it is known as the *margo obtusus vel rotundus*. The marginal branch of the left coronary artery lies along it.

Interior of the Heart—Right Auricle.—The wall of the auricular appendix is marked by a number of muscular elevations, arranged as closely-set, vertical, parallel bands, like the teeth of a comb, from which circumstance they are called the *musculi pectinati*. These bands, relatively to each other, are more or less reticular. They are also present on the right wall of the atrium, being more comb-like here than in the appendix, and they terminate posteriorly at a vertical ridge, called the *crista terminalis*. This crest corresponds in position to the sulcus terminalis externally, and it has the same significance. Internally and posteriorly the walls of the auricular atrium are destitute of musculi pectinati, and present a smooth appearance. The atrium of the right auricle presents the following **openings**: the opening of the superior vena cava; the opening of the inferior vena cava; the opening of the coronary sinus; the foramina Thebesii; and the auriculo-ventricular opening.

The **orifice of the superior vena cava,** which is destitute of a valve, is situated at the postero-superior angle of the atrium. It is directed downwards and forwards, and the upper part of the crista vestibuli is continuous with its anterior margin.

The **orifice of the inferior vena cava** is situated at the postero-inferior angle of the atrium, and is directed upwards and inwards. In front of the orifice, and to a certain extent overlapping it, there

is a crescentic fold of endocardium, which is the remains of the *Eustachian valve* of fœtal life. The convexity of the crescent is continuous with the anterior margin of the orifice of the vein, and the inner horn of the crescent is continuous with the anterior limb of the annulus ovalis, to be presently described. The fold is a somewhat indefinite structure in the adult, being subject to much variety as regards size, and sometimes presenting several small openings. During fœtal life, however, the Eustachian valve is of the utmost importance, inasmuch as it directs the blood entering by the inferior vena cava through the foramen ovale into the left auricle.

The **orifice of the coronary sinus** is situated between the vestigial Eustachian valve and the auriculo-ventricular orifice. It is

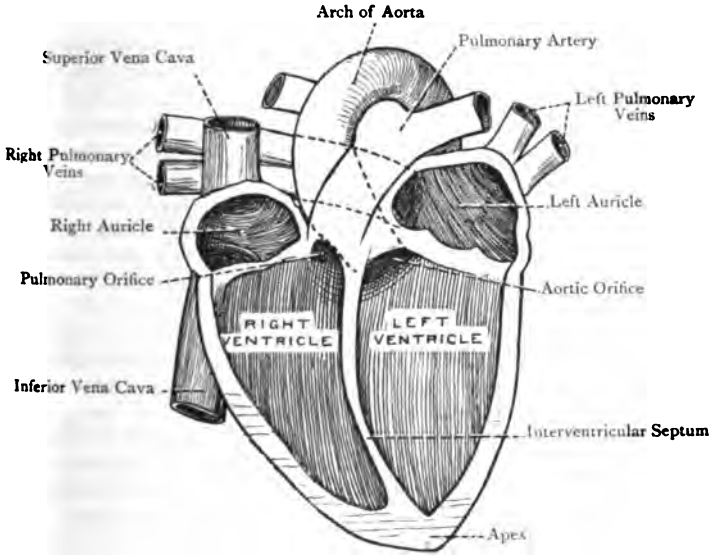


FIG. 386.—DIAGRAMMATIC VIEW OF THE INTERIOR OF THE HEART (AFTER MILNE EDWARDS).

guarded by a delicate semicircular fold of the endocardium, called the *coronary valve*, or *valve* of *Thebesius*, which, however, is functionally incompetent.

The **foramina Thebesii** represent several minute openings on the wall of the atrium. Some of these are simply blind recesses, whilst others are the orifices of minute veins, called the *venæ minimæ cordis*, which return the blood from the wall of the auricle.

The **auriculo-ventricular, or tricuspid, orifice** is situated in the lower and anterior part of the atrium, in front of the orifice of the inferior vena cava, with the intervention of that of the coronary sinus. It is oval, and, in health, the index, middle, and ring fingers,

held close together and side by side, can be passed through it without difficulty. Through this opening the blood passes from the right auricle into the right ventricle, its return being prevented by the tricuspid valve, which will be described in connection with the right ventricle.

The so-called *tubercle of Lower* is an unimportant slight projection, which is situated on the interauricular septum, just below the opening of the superior vena cava and behind the upper part of the fossa ovalis.

The posterior wall of the atrium corresponds to the *interauricular septum*, and it presents for consideration the fossa ovalis and the annulus ovalis.

The **fossa ovalis** is an oval depression which is situated upon the lower part of the interauricular septum, a little above and to the left of the orifice of the inferior vena cava. It indicates the position of the *foramen ovale* of the fœtal heart, which is a communication between the two auricles through which the blood entering the right auricle by the inferior vena cava passes into the left auricle. The floor of the fossa ovalis is very thin, and is bounded above and at the sides by a prominent, crescentic margin, called the **annulus ovalis.** The annulus is deficient below, and the concavity of the crescent is directed downwards. Its anterior limb is continuous with the vestigial Eustachian valve. In some cases a minute oblique communication between the two auricles persists in the adult, being situated under cover of the upper portion of the annulus ovalis.

Interior of the Right Ventricle.—When exposed to view in the ordinary way the interior of the right ventricle is triangular, the base being directed backwards and upwards, and the apex forwards and downwards. It is completely separated from the left ventricle by the interventricular septum, which forms the posterior wall of the ventricle, and bulges into it so as to be convex towards it. In transverse section, therefore, the right ventricle is semilunar. Its wall, which is about three times thinner than that of the left ventricle, is thickest at the base, and becomes thinner towards the apex. The capacity of the ventricle is about 4 ounces. Its upper and left part forms the *infundibulum* or *conus arteriosus*, from the upper part of which the trunk of the pulmonary artery springs. The walls of the infundibulum are smooth, but elsewhere the walls of the ventricle are elevated into muscular bands, called *columnæ carneæ*. These project into the cavity, and, from their reticular arrangement, they render the wall very irregular. According to the manner in which the columnæ corneæ are attached to the wall, they are arranged in three sets: (1) some are simple elevations, which are attached to the wall by their entire length, as well as by their extremities; (2) some are attached to the wall only by their extremities, being free elsewhere; and (3) others are attached only by one extremity. These latter are called *musculi papillares*. They are conical, and their bases are attached to the

wall of the ventricle. Their free extremities are connected with a number of filiform processes, called *chordæ tendineæ*, which pass to the margins and ventricular surfaces of the segments of the auriculo-ventricular valve. When the ventricle contracts, the musculi papillares also contract, and, by tightening the chordæ tendineæ, they prevent the segments of the auriculo-ventricular valve from being driven back into the auricle. The segments are therefore maintained in contact during the ventricular systole, and no regurgitation of blood from the ventricle into the auricle is allowed, in health. The musculi papillares are arranged in two groups, anterior and posterior, and their bases are attached to the

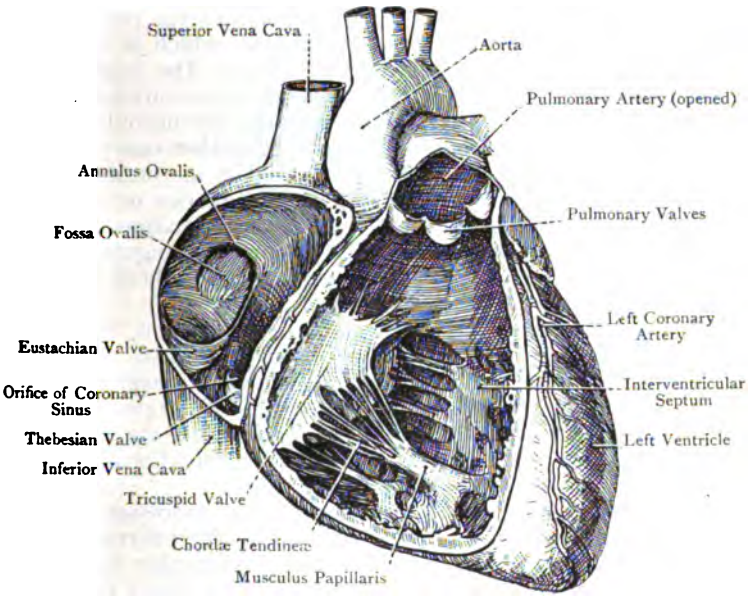


FIG. 387.—THE INTERIOR OF THE RIGHT AURICLE AND RIGHT VENTRICLE.

wall of the ventricle in the region of the apex of the cavity. The anterior musculus papillaris is of large size, and the posterior is usually broken up into two or more secondary papillary muscles.

In most hearts a fleshy column, called the *moderator band*, is met with in the right ventricle, which extends from the interventricular septum to the base of the anterior papillary muscle. It is regarded as controlling distension of the right ventricle, which it effects by the influence it exerts upon the anterior wall.

The **openings** connected with the right ventricle are two in number, namely, the auriculo-ventricular and pulmonary. They are situated at the base of the cavity, and are guarded by most important valves. The auriculo-ventricular orifice is situated on the

right and posteriorly, whilst the pulmonary orifice is situated on the left and anteriorly, being also on a higher level than the other. *Venæ minimæ cordis* are said to open into the right ventricle.

The **auriculo-ventricular,** or **tricuspid, orifice** is, as already stated in connection with the right auricle, oval, and it readily admits the index, middle, and ring fingers held close together. It allows the venous blood to flow from the right auricle into the right ventricle, and, in order to prevent regurgitation of blood from the ventricle into the auricle during the ventricular systole, it is guarded by an important valve, called the **right auriculo-ventricular** or **tricuspid valve.** This valve is composed of three segments or *cusps*, which are covered with endocardium. These project into the cavity of the ventricle, and are triangular. The bases of the cusps are continuous with one another, and form a ring, which is attached to the margin of the auriculo-ventricular orifice. The largest cusp is situated in front, and to the left, of the auriculo-ventricular orifice. It intervenes between that orifice and the infundibulum, and is known as the *left* or *infundibular cusp*. Another cus pis situated behind the auriculo-ventricular orifice, and is in contact with the interventricular septum. It is called the *posterior* or *septal cusp*. The third cusp is situated to the right, near the margo acutus, and is called the *right* or *marginal cusp*. In the angular intervals between the basal parts of the three large cusps there are usually three small cusps.

Each cusp consists of two layers of endocardium, with fibrous tissue between them, especially at their central parts. The middle portion of each cusp is therefore thicker than the marginal portions, these latter being thin and transparent. The margins themselves are notched. The auricular surfaces of the cusps are smooth, but their ventricular surfaces are roughened by the chordæ tendineæ, which are also attached to the margins.

The **chordæ tendineæ** are filiform, fibrous processes which are connected, on the one hand, with the wall of the ventricle, and, on the other, with the cusps of the auriculo-ventricular valve. Most of them spring from the two papillary muscles, but a few of them arise from the interventricular septum and from small papillary eminences upon it. Those which are connected with the anterior papillary muscle pass to the interval between the infundibular and marginal cusps; those which are connected with the posterior papillary muscle and its subdivisions pass to the interval between the septal and marginal cusps; and those which are connected with the interventricular septum pass to the interval between the infundibular and septal cusps. The connection of the chordæ tendineæ with the cusps of the valve is of a threefold nature, as follows: (1) the most numerous are connected with the marginal parts of the cusps; (2) others are connected with the thickened central portion of each cusp; and (3) a few pass to the basal portion of each cusp, where they are connected with the fibrous ring around the auriculo-ventricular orifice.

The **pulmonary valve** guards the orifice of the pulmonary artery, and prevents regurgitation of blood from the trunk of the pulmonary artery into the right ventricle during the elastic recoil of the arterial wall. It is composed of three semilunar or sigmoid segments, and the wall of the artery, opposite each segment, presents a recess, these recesses being called the **sinuses of Valsalva.** The valve and the sinuses of Valsalva are similar to corresponding structures in connection with the aortic orifice, and will be fully described along with that orifice.

Interior of the Left Auricle.—The musculi pectinati are present *only* in the auricular appendix, whereas in the right auricle they are

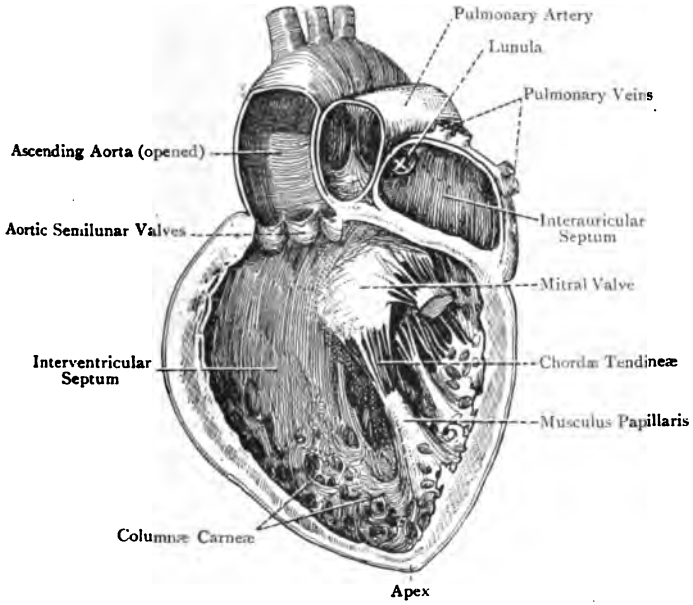


FIG. 388.—THE INTERIOR OF THE LEFT AURICLE AND LEFT VENTRICLE.

present both in the auricular appendix and on the right wall of the atrium. The wall of the left atrium is entirely smooth. The atrium presents five **openings,** namely, the openings of the four pulmonary veins, and the auriculo-ventricular opening.

The **orifices of the four pulmonary veins** are situated on the posterior wall at either side, two right and two left, and they are destitute of valves.

The **auriculo-ventricular,** or **mitral, orifice** is situated in the anterior part of the floor of the atrium. It is oval, and, in health, it admits two fingers held side by side, and in close contact.

Venæ minimæ cordis are said to open into the left auricle.

The *interauricular septum* presents a slight depression, limited inferiorly by a faint crescentic ridge, the concavity of which is directed upwards. These indicate the position of the foramen ovale of the fœtal heart.

Interior of the Left Ventricle.—The cavity of the left ventricle extends quite to the apex of the heart, and is longer and narrower than that of the right ventricle. It is somewhat conical, the base being directed backwards and upwards. The interventricular septum recedes from the cavity, and is concave towards it. In transverse section, therefore, the left ventricle is oval, or nearly circular. The wall of the left ventricle is about three times thicker than that of the right, the difference being readily accounted for by the fact that the left ventricle is concerned with the systemic circulation, whilst the right ventricle has to do with the pulmonary circulation, the latter involving a much shorter circuit. The wall of the left ventricle attains its maximum thickness about the junction of the upper fourth and lower three-fourths, and it is thinnest in the region of the apex. The capacity of the ventricle is about 4 ounces. The portion of the cavity immediately below the aortic orifice is known as the **aortic vestibule**, the walls of which are *fibrous*.

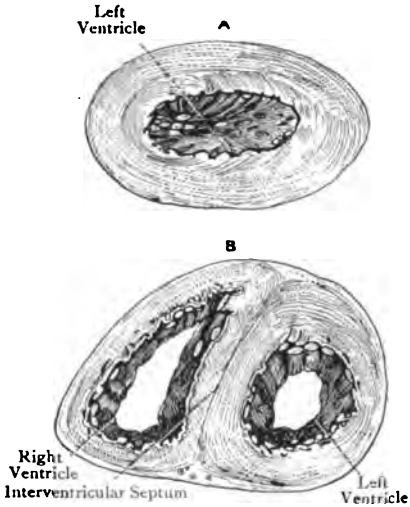


FIG. 389.—TRANSVERSE SECTIONS OF THE HEART.

A, Through Apex (Superior View).
B, Through Ventricles (Inferior View).

The left ventricle, like the right, is provided with columnæ carneæ. They are arranged in a very intricate manner, more particularly in the region of the apex and over the posterior wall. The aortic vestibule, and the interventricular septum, at least over its upper part, are destitute of columnæ carneæ, and present a smooth appearance. The musculi papillares are much larger than those in the right ventricle ; they are two in number, anterior and posterior ; and they are attached by their bases to the respective walls of the ventricle, whilst their free ends are connected with the chordæ tendineæ.

The **openings** connected with the left ventricle are two in number, namely, auriculo-ventricular and aortic. They are situated at the base of the ventricle in close proximity to each other, and are guarded by important valves. The auriculo-ventricular orifice is

situated on the left and posteriorly, whilst the aortic orifice is situated on the right and anteriorly. The aortic orifice is also the higher of the two. *Venæ minimæ cordis* are said to open into the left ventricle.

The **auriculo-ventricular,** or **mitral, orifice** is oval, and, in health, it admits two fingers held side by side. It allows the arterial blood to flow from the left auricle into the left ventricle, and, in order to prevent regurgitation of blood from the ventricle into the auricle during the ventricular systole, it is guarded by an important valve. This valve is called the **left auriculo-ventricular, mitral,** or **bicuspid valve.** It is composed of two large segments or *cusps*, with two small cusps in the angular intervals between their basal parts. The cusps are similar in shape and structure to those of the tricuspid valve, but, on account of the nature of their work, they are thicker and stronger. They are disposed obliquely, and are of unequal

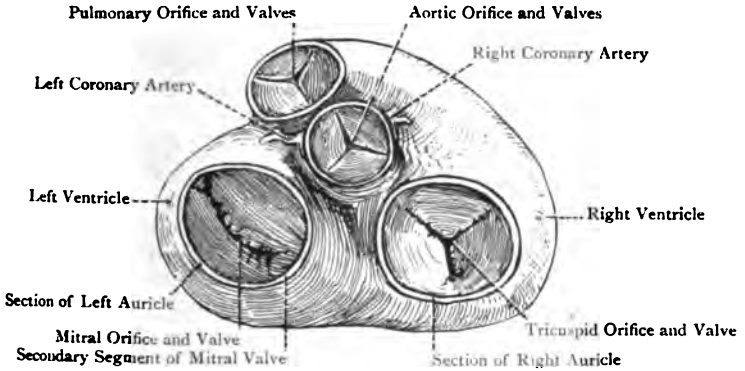


FIG. 390.—THE AURICULO-VENTRICULAR AND ARTERIAL ORIFICES OF THE HEART, WITH THEIR VALVES (SUPERIOR VIEW).

(The Auricles have been removed.)

size. The larger of the two is placed in front, and to the right, of the orifice. It intervenes between the auriculo-ventricular and aortic orifices, and is known as the *anterior* or *aortic cusp*. The smaller cusp is placed behind, and to the left, of the orifice, and is known as the *posterior* or *marginal cusp*.

The **chordæ tendineæ** are attached to the cusps, as in the case of the tricuspid valve. They are, however, fewer in number, and of greater thickness and strength, than on the right side.

Function of the Tricuspid and Mitral Valves.—These valves serve to prevent regurgitation of blood from the ventricles into the auricles during the ventricular systole. Whilst the ventricle is being filled, some of the blood gets behind the segments of the auriculo-ventricular valve, that is to say, between each segment and the wall of the ventricle, and the segments are thus carried towards the auriculo-ventricular orifice. When the ventricle is

filled with blood, the segments are in contact, and the ventricular systole now takes place. At the same time the musculi papillares contract. Blood is forced against the segments of the valve, but it cannot, in health, enter the auricle, because the segments are maintained in close contact, and are prevented from being driven back into the auricle, by the chordæ tendineæ, which are under the control of the musculi papillares. If there were no musculi papillares, in which case the chordæ tendineæ would spring directly from the wall of the ventricle, then the segments of the valve would not be held tight, but would, under the pressure of the blood, be driven back into the auricle, and regurgitation of blood would of necessity occur. The explanation of this lies in the fact that when the ventricle contracts a kind of screwing up or wringing movement takes place in its wall, as, so to speak, in wringing a wet towel. The effect of this peculiar action is to approximate successive parts of the ventricular wall to the auriculo-ventricular orifice, and this would have the effect of relaxing the chordæ tendineæ, and so allowing the segments of the valve to be driven back into the auricle. The chordæ tendineæ, however, spring from musculi papillares, and these are elevations of the wall of the ventricle, directed *towards* the auriculo-ventricular orifice. During the wringing movement, therefore, of the ventricular wall in systole the musculi papillares, as stated, contract, and so maintain the chordæ tendineæ taut, or tightly drawn.

When the mitral valve opposes the entrance of blood into the left ventricle the cardiac affection is known as mitral obstruction (stenosis). When the mitral valve is incompetent, and allows regurgitation of blood to take place from the left ventricle into the left auricle, the cardiac affection is known as mitral regurgitation (incompetence).

The **aortic orifice** is circular, and is separated from the auriculo-ventricular orifice by the anterior or aortic cusp of the mitral valve. It is guarded by the **aortic valve,** which, by means of its segments, prevents regurgitation of blood from the aorta into the left ventricle during the elastic recoil of the arterial wall. It is composed of three semilunar or sigmoid segments, consisting of fibrous tissue, covered on their ventricular surfaces by endocardium, and on their

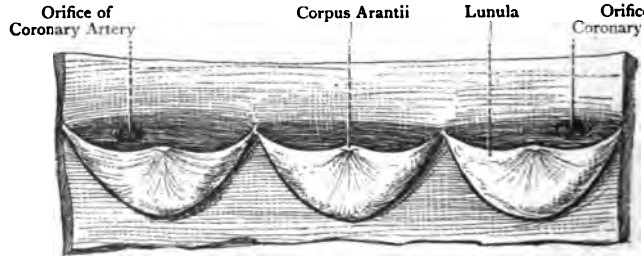


FIG. 391.—THE AORTIC SEMILUNAR VALVES.

arterial surfaces by the endothelial lining of the artery. Each segment is attached by its convex border to the wall of the artery at the place where it springs from the ventricle. The other border of the segment is free, and is directed away from the ventricle. Each segment, therefore, is so disposed as to allow the blood to pass freely into the aorta from the left ventricle. The free border of each segment is strengthened by a band of fibrous tissue, and at

the centre of the border there is a small swelling, called the *nodule* or *corpus Arantii*. This gives rise to a slight projection, and on either side of it the border is concave. The attached convex border of each segment is also strengthened by fibrous tissue. In addition to these fibrous thickenings, fibrous tissue pervades each segment from the nodule to the attached border, with the exception of the portions immediately below the lateral concave parts of the free border. These portions, in each segment, are semilunar, and are called the *lunulæ*. They are the thinnest parts of the segment, and are transparent, consisting practically of endocardium and the endothelial lining of the artery.

The interior of the wall of the aorta presents three well-marked recesses, each of which is placed opposite a segment of the valve. These recesses are called the **sinuses of Valsalva,** and they are disposed as *right antero-lateral*, *left antero-lateral*, and *posterior*, respectively. The right antero-lateral sinus of Valsalva presents the orifice of the right coronary artery, and the left antero-lateral sinus of Valsalva presents the orifice of the left coronary artery. Each sinus of Valsalva, together with the corresponding segment of the aortic valve, forms a small pocket, and the three pockets open away from the left ventricle, that is to say, in a direction corresponding to the normal blood-flow.

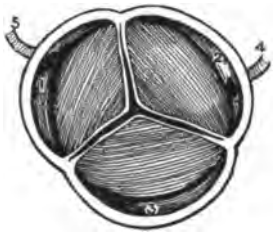


FIG. 392.—THE SEMILUNAR VALVES OF THE AORTA (SUPERIOR VIEW).

1, Left Antero-lateral Sinus of Valsalva; 2, Right Antero-lateral Sinus of Valsalva; 3, Posterior Sinus of Valsalva; 4, Right Coronary Artery; 5, Left Coronary Artery.

Function of the Aortic Valve.—This valve serves to prevent regurgitation of blood from the aorta into the left ventricle during the elastic recoil of the arterial wall close to the heart. During the ventricular systole, when the blood is being driven through the aortic orifice, the aortic valve is passive, and its three segments are applied to the arterial wall. During the elastic recoil of the arterial wall, however, the valve is in action. The first effect of the elastic recoil is to force sufficient blood backwards towards the left ventricle to close the aortic valve. This blood enters the pockets formed by the sinuses of Valsalva and the segments of the valve. The segments are pressed towards the centre of the aortic orifice, and they come into contact in the following manner: the three nodules or corpora Arantii come into close contact at the centre of the aortic orifice, and so close what would otherwise be a small space, and the respective lunulæ are closely pressed against one another. In this manner the aortic orifice is completely closed, and regurgitation of blood into the left ventricle is, in health, effectually guarded against. It will be evident that the strain of the backward pressure of blood must be borne by those portions of the segments which are strengthened by fibrous tissue extending from each nodule to the attached border of each segment. Though the lunulæ are thin and weak, nevertheless, being, so to speak, doubled up against one another, the more they are pressed upon the more closely they fit together.

When the aortic valve offers opposition to the entrance of blood into the aorta, the cardiac affection is called aortic obstruction (stenosis). On the

other hand, when the aortic valve is incompetent, and allows regurgitation of blood to take place into the left ventricle, the cardiac affection is called aortic regurgitation (incompetence).

The **pulmonary valve,** which guards the orifice of the pulmonary artery, is similar to the aortic valve, and the preceding description is, for the most part, applicable to it. The segments of the pulmonary valve are, however, weaker than those of the aortic valve, and the **sinuses of Valsalva** are destitute of any arterial orifices. These sinuses are disposed as *anterior, right postero-lateral,* and *left postero-lateral,* respectively.

The function of the pulmonary valve is similar to that of the aortic valve.

Interventricular Septum.—This septum completely separates the right and left ventricles. The external indications of its attachments are the antero-superior and inferior interventricular grooves. It is thick and, for the most part, fleshy. It is thickest in the region of the apex, and becomes thinner towards the base of the ventricles. It bulges into the right ventricle, so as to be convex on that aspect, whilst it recedes from the left ventricle, so as to be concave towards it. The upper or basal part of the septum presents anteriorly a small portion which is destitute of muscular fibres. This portion is thin, and consists of fibrous tissue, covered on either side by endocardium. It is known as the *pars membranacea septi,* and is developed from the lower part of the septum which divides the aortic bulb into the ascending aorta and trunk of the pulmonary artery. It forms part of the aortic vestibule of the left ventricle. In rare cases the interventricular septum is deficient in the region of the pars membranacea, and a communication thus exists between the right and left ventricles.

Topography of the Orifices of the Heart.—The **pulmonary orifice** is situated on a level with the upper margin of the third left costal cartilage at its junction with the sternum. The **aortic orifice,** which is more deeply placed than the pulmonary, is situated behind the left border of the sternum on a level with the lower margin of the third left costal cartilage.

The **tricuspid orifice** lies behind the body of the sternum opposite the fourth intercostal spaces and fourth and fifth costal cartilages. The **mitral orifice,** which is placed very deeply, is situated behind the left border of the sternum on a level with the fourth left costal cartilage.

Cardiac Bloodvessels—Arteries.—The nutrient vessels of the heart are the coronary arteries, right and left, which arise from the root of the ascending aorta. For a description of these vessels, see p. 901.

Veins.—The cardiac veins are as follows : the great or left cardiac or coronary vein ; the coronary sinus ; the posterior cardiac veins ; the middle cardiac vein ; the right or small cardiac or coronary vein ; the anterior cardiac veins ; the oblique vein of Marshall ; and the venæ minimæ cordis or smallest cardiac veins. With the

exception of the last-named cardiac veins (venæ minimæ cordis), all the others are seen upon the exterior of the heart.

The **great** or **left cardiac** or **coronary vein** commences at the apex of the heart, and ascends in the antero-superior interventricular groove alongside of the descending branch of the left coronary artery. In this part of its course it is more properly called the *antero-superior interventricular vein*. It is of large size, and receives tributaries from both ventricles and from the inter-

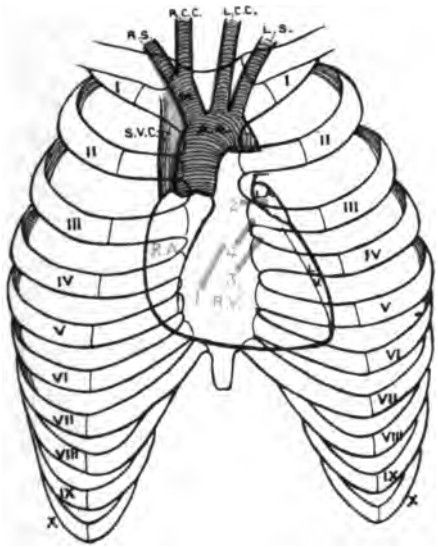


FIG. 393.—DIAGRAM SHOWING THE POSITION OF THE HEART AND ITS VALVULAR ORIFICES IN RELATION TO THE ANTERIOR WALL OF THE THORAX.

R.A. Right Auricle
R.V. Right Ventricle
L.A. Left Auricle
L.V. Left Ventricle
A.A. Arch of Aorta
IN. Innominate Artery
R.S. Right Subclavian Artery
R.C.C. Right Common Carotid Artery
L.C.C. Left Common Carotid Artery
L.S. Left Subclavian Artery
S.V.C. Superior Vena Cava

NUMBERS ON STERNUM.

1. Tricuspid Orifice
2. Pulmonary Orifice
3. Mitral Orifice
4. Aortic Orifice

ventricular septum. On reaching the auriculo-ventricular groove, it enters the left division of that groove, in which it courses along with the transverse branch of the left coronary artery. Having turned round the left margin of the heart, it joins the left extremity of the coronary sinus, with which it is continuous. The name *coronary* is strictly applicable to this vessel only where it lies in the left auriculo-ventricular groove.

The **coronary sinus** (see Fig. 385, p. 917) is the dilated terminal

part of the great cardiac vein. It is about 1 inch in length, and occupies a portion of the posterior part of the left auriculo-ventricular groove. Its left extremity is continuous with the great cardiac vein, and its right extremity opens into the right auricle between the vestigial Eustachian valve and the auriculo-ventricular orifice, the opening being guarded by the Thebesian valve. At the place where the coronary sinus is continuous with the great cardiac vein there is a valve, which is composed of two segments.

The coronary sinus is the persistent terminal part of the *left duct of Cuvier*.

The **posterior cardiac veins** ascend upon the inferior surface of the left ventricle, and open partly into the coronary sinus, and partly into the contiguous portion of the great cardiac vein. One of them is known as the *left marginal vein*.

The **middle cardiac vein** (more properly called the *inferior interventricular vein*), which is of large size, commences at the apex of the heart, and passes along the inferior interventricular groove with the descending branch of the right coronary artery. It receives tributaries from the adjacent surface of the right ventricle and from the interventricular septum, as well as a few from the left ventricle, and it opens into the right extremity of the coronary sinus.

The **right** or **small cardiac** or **coronary vein** occupies the right auriculo-ventricular groove, in company with the right coronary artery, and it opens into the right extremity of the coronary sinus. It is subject to some variation, but it usually receives tributaries from the contiguous parts of the right auricle and right ventricle, including the anterior cardiac veins.

The **anterior cardiac veins** ascend on the front of the right ventricle, and open into the right cardiac vein. One of them is known as the *right marginal vein*.

The **oblique vein of Marshall,** which is a persistent part of the *left duct of Cuvier*, passes downwards and inwards over the posterior aspect of the left auricle, and opens into the left extremity of the coronary sinus, its orifice being destitute of a valve.

Tributaries of the Coronary Sinus.—These are as follows : (1) the great or left cardiac vein ; (2) some of the posterior cardiac veins, others of these veins opening into the great cardiac vein ; (3) the middle cardiac vein ; (4) the right cardiac vein ; and (5) the oblique vein of Marshall. With the exception of the last-named tributary, all the others are provided with valves at their terminal orifices, but elsewhere they are destitute of valves.

The **smallest cardiac veins,** or *venæ minimæ cordis*, also known as the *venæ Thebesii*, are not visible upon the exterior of the heart. They are very minute, and they open into the right auricle, their orifices constituting some of the foramina Thebesii. Similar minute veins are said to open into the left auricle, and also into both ventricles.

Lymphatics. — The lymphatics of the heart are very numerous,

and are present in the muscular substance, as well as beneath the epicardium and endocardium. On the surface of the heart they form a plexus, from which two trunks, right and left, issue. These trunks pass backwards, one on either side of the trunk of the pulmonary artery, to the superior mediastinal glands, and thence to the right lymphatic duct and thoracic duct respectively.

Nerves.—The nerves of the heart are derived from the superficial and deep cardiac plexuses, and, through these, from the pneumogastric and sympathetic nerves. The branches to the auricles are derived partly from the deep cardiac plexus, and partly from the coronary plexuses. They form a gangliated plexus on the surface of each auricle beneath the epicardium, and from this plexus branches proceed to the muscular wall. The branches to the ventricles are derived from the right and left coronary plexuses. These branches lie upon the surface of each ventricle beneath the epicardium, and in the heart of the calf they are readily recognisable as delicate, thread-like streaks. Minute ganglia are met with, at intervals, on these nerves in the region of the base of the ventricles, but none on those nerves which lie over the lower two-thirds of each ventricle. The branches which enter the muscular substance of the ventricular walls form plexuses, but are destitute of ganglia.

Structure of the Heart.—The cardiac wall is composed of muscular tissue, which is known as the **myocardium.** This is intimately covered by the visceral layer of the serous portion of the pericardium, this layer being called the **epicardium,** and the cavities of the heart are lined with a membrane which is known as the **endocardium.**

The **epicardium** resembles a serous membrane in structure, and is covered by endothelium. It is provided with *stomata*, which establish a communication between its lymph-canalicular system and the cavity of the pericardium. Beneath the epicardium there is a variable amount of fat, which is chiefly met with in the auriculo-ventricular and interventricular grooves.

The **endocardium** is a smooth, delicate membrane, destitute of blood-vessels, and covered on its internal surface by endothelium. It consists of a connective-tissue basement membrane, containing elastic fibres, and is continuous, through the arterial and venous orifices, with the *tunica intima* of the vessels. It enters into the formation of the segments of the auriculo-ventricular and semilunar valves.

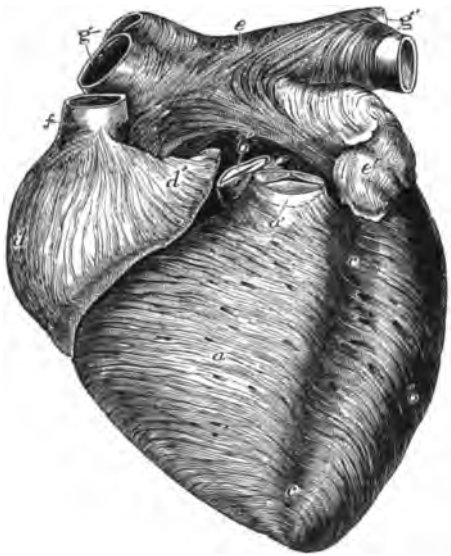
Fibrous Tissue.—The auriculo-ventricular and arterial orifices of the heart are each surrounded by a ring of fibrous tissue, and these rings, in the case of the auricles and ventricles, connect them together. The fibrous tissue of these rings furnishes that which is met with in the segments of the various valves. In the triangular interval between the aortic and the two auriculo-ventricular orifices there is a collection of dense fibrous tissue, of the consistence of fibro-cartilage, which is connected with the fibrous rings just referred to. When a heart is boiled, the fibrous tissue is dissolved, and the auricular portion can be separated from the ventricular portion.

Myocardium.—The muscular tissue of the auricles is quite distinct from that of the ventricles, the fibrous rings at the auriculo-ventricular orifices intervening between the two, and serving to connect them.

Auricles.—The muscular fasciculi of the auricles are arranged in a superficial set, common to both auricles, and a deep set, confined to each auricle. The *superficial fasciculi* are disposed transversely, and some of them enter the interauricular septum. They are best marked in front. The *deep fasciculi* are arranged in two sets, looped and circular. The *looped fasciculi*

arch vertically over the auricle, their extremities being attached to the ring of fibrous tissue which surrounds the auriculo-ventricular orifice. The *circular fasciculi* are present in the auricular appendix, around the venous orifices, and around the fossa ovalis. The walls of the auricles, though muscular, are thin.

Ventricles.—The muscular fasciculi of the ventricles are, as stated, quite distinct from those of the auricles, and are disposed in a very complicated manner. They spring, for the most part, from the rings of fibrous tissue which surround the auriculo-ventricular orifices. The *superficial fasciculi* descend obliquely towards the apex, where they are disposed in a twisted or whorled manner, after which they pass on to the inner surface of the left ventricle. Some of them become continuous with the musculi papillares of that ventricle, whilst others ascend as a vertical layer on the inner surface of the ventricle to be attached to the left auriculo-ventricular fibrous ring. The superficial fasciculi are common to both ventricles.



This figure is planned after one of Luschka's, but its details were chiefly taken from an original preparation. The aorta, *b'*, and pulmonary artery, *a'*, have been cut short close to the semilunar valves, so as to show the anterior fibres of the auricles. *a*, superficial layer of the fibres of the right ventricle; *b*, that of the left; *c*, *c*, anterior interventricular groove; *d*, right auricle; *d'*, its appendix, both showing chiefly perpendicular fibres; *e*, upper part of the left auricle; between *e* and *b'*, the transverse fibres which behind the aorta pass across both auricles; *e'*, appendix of left auricle; *f*, superior vena cava, around which, near the auricle, circular fibres are seen; *g*, *g'*, right and left pulmonary veins with circular bands of fibres surrounding them.

FIG. 394.—ANTERIOR VIEW OF HEART OF A YOUNG SUBJECT DISSECTED AFTER LONG BOILING, TO SHOW THE SUPERFICIAL MUSCULAR FIBRES (ALLEN THOMSON). ⅔. (FROM QUAIN'S 'ANATOMY.')

The remaining fasciculi are very numerous, and must be described separately for each ventricle. The principal fasciculi of the *left* ventricle spring from the left auriculo-ventricular fibrous ring, and they pass more or less obliquely towards the apex. In their course they turn inwards, and enter the front part of the interventricular septum inferiorly. Some of them now pass upwards to the base of the ventricle to be attached to the collection of dense fibrous tissue, of the consistence of fibro-cartilage, already described; others pass across to the postero-inferior wall of the right ventricle, where they partly end in a musculus papillaris, and partly pass to be attached to the right auriculo-ventricular fibrous ring; whilst a third set pass to the postero-inferior wall of the left ventricle, where they become circular in direction. The principal fasciculi of the *right* ventricle are, like the superficial fasciculi, continuous with those of the left ventricle, and they spring from the fibrous rings around the auriculo-ventricular and pulmonary orifices.

Those on the postero-inferior surface of the right ventricle pass into the interventricular septum, and, having traversed it obliquely forwards and upwards, they issue from it, and become continuous with the deep fibres of the left ventricle. Those on the antero-superior surface of the right ventricle also pass into the interventricular septum, and having traversed it obliquely backwards and downwards, they pass on to the postero-inferior wall of the left ventricle. Those from the inferior aspect of the right ventricle enter the lower part of the interventricular septum, and ascend in the septum to the collection of dense fibrous tissue of the consistence of fibro-cartilage at the base. Although the ventricular muscular fasciculi are disposed for the most part obliquely, there are some circular fasciculi, but these are confined to the thickest part of each ventricular wall.

FIG. 395. — THE SUPERFICIAL MUSCULAR FIBRES OF THE HEART IN THE REGION OF THE APEX (C. GEGENBAUR).

The whorled arrangement is well shown.

Structure of the Cardiac Valves.—Each segment of the tricuspid and mitral valves consists of two layers of endocardium, enclosing between them fibrous tissue which is derived from the fibrous ring around the corresponding auriculo-ventricular orifice. Each segment of the aortic and pulmonary valves also consists of two layers of endocardium, enclosing between them fibrous tissue which is derived from the fibrous ring around the corresponding arterial orifice. The segments of all the valves are destitute of bloodvessels.

FIG. 396.—CARDIAC MUSCULAR FIBRES, SHOWING THEIR TRANSVERSE STRIÆ, DIVISIONS, JUNCTIONS, AND POSITION OF THE NUCLEI.

Minute Structure of the Myocardium.—Cardiac muscle is composed of transversely striated fibres, but these differ so much from ordinary striated voluntary muscular fibres as to require a special description. They possess no sarcolemma; they branch freely, and adjacent branches unite, so that an intricate network is formed by them; and the transverse striæ are fainter and less regular than those of voluntary muscle. Each fibre and its branches are broken up into a series of short quadrangular *muscle-corpuscles*, arranged in rows or chains, and separated from one another by cross-marks. Each muscle-corpuscle contains one nucleus, which occupies *the centre* of the corpuscle and the corpuscle presents longitudinal striæ as well as transverse. A cardiac muscular fibre, as well as its branches, is therefore a chain of muscle-corpuscles, each of which has a nucleus at its centre, and there is an absence of sarcolemma.

Weight of the Heart.—The average weight of the heart of the adult male is 10½ ounces, and of the adult female 8½ ounces.

Size.—The size of a normal heart has been compared to the closed hand of the individual person.

Development of the Heart.—The primitive heart makes its appearance as *two tubes*, one on either side, in the splanchnic mesoblast in the region of the head. When this mesoblast turns round, on either side, to form the fore-gut, these two tubes become approximated, and they unite along the median line to form a *single longitudinal tube*. This tube represents the primitive heart, and is situated on the ventral aspect of the fore-gut. Its anterior extremity divides into

two branches—the primitive aortæ, which pass backwards on either side of the fore-gut, forming the first aortic arches, and then on either side of the notochord. The posterior extremity of the single tube divides into two vessels, which diverge and become the vitelline or omphalo-mesenteric veins for the return of blood from the vascular area on the yolk-sac. The tube (primitive heart) soon describes two bends, which impart to it the shape of a capital S, and constrictions make their appearance so as to divide it into the following four parts: (1) the sinus venosus; (2) the auricular portion; (3) the ventricular portion; and (4) the aortic bulb, or bulbus arteriosus.

The **sinus venosus** consists of a central part and two lateral enlargements or cornua, one on either side. Into each lateral cornu there open (1) the vitelline or omphalo-mesenteric vein, (2) the umbilical vein, and (3) the primitive superior vena cava, or duct of Cuvier. The communication between the sinus venosus and the auricular portion soon becomes small, and assumes a position between the right lateral cornu of the sinus and the right half of the auricular portion, where it is guarded by a right and left valve. The right lateral cornu undergoes enlargement, and the left lateral cornu becomes prolonged into the left duct of Cuvier. At this stage, in which the sinus venosus has a large right lateral cornu and a small left lateral cornu, the sinus is known as the *saccus reuniens of His*, and it lies transversely below and behind the auricular portion of the primitive heart. At a later stage all the

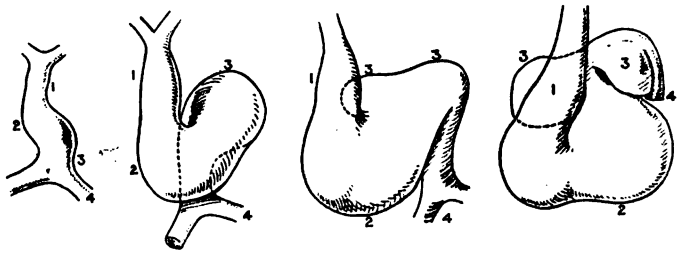


FIG. 397.—SCHEME SHOWING FOUR SUCCESSIVE STAGES IN THE DEVELOPMENT OF THE HEART (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Arterial Bulb. 2. Ventricle. 3. Auricle.
4. Veins opening into the Sinus Venosus.

veins, except the left duct of Cuvier, open into the right lateral cornu; the communication between the right lateral cornu and the right half of the auricular portion becomes enlarged; and the right lateral cornu becomes absorbed into the right half of the auricular portion. The left valve disappears, and the right valve gives rise to the Eustachian and Thebesian valves. The transverse part of the sinus venosus, through means of the left lateral cornu, is continuous with the left duct of Cuvier, which latter persists as the *coronary sinus*.

The **ventricular portion** of the heart is connected at its left extremity with the auricular portion, and at its right extremity it turns upwards and is continued into the aortic bulb. Its interior becomes divided into right and left ventricles by means of a muscular septum which is gradually developed in a direction upwards and backwards. This septum remains incomplete superiorly for some time, so that the two ventricles are here in communication with each other. Subsequently, however, the septum is completed superiorly by (1) an extension from the partition which divides the aortic bulb into the ascending aorta and the trunk of the pulmonary artery, and (2) an extension from the endocardial growths, which by their fusion divide the single orifice between the auricle and ventricle into right and left auriculo-ventricular orifices. The upper portion of the septum, formed in this manner, represents the *pars membranacea septi* of the adult heart.

The opening between the auricle and ventricle, which has gradually shifted from the left extremity of the ventricular portion to its upper and back part, becomes elongated into the *auricular canal*. The opening of this canal into the ventricle ultimately becomes shifted till it lies over the position of the ventricular septum. The margins of the opening then become thickened by endocardial growths, and these come together at the centre of the orifice and fuse. In this manner the single orifice becomes divided into right and left auriculo-ventricular orifices. From the fusion of the endocardial growths an extension grows downwards, as stated, to meet the upwardly-rising ventricular septum.

The division of the auricular portion into two auricles, right and left, is effected by means of a septum, called the **septum primum,** which grows gradually downwards and forwards from the upper and back part of the cavity. This septum eventually joins the fused endocardial growths which divide the single auricular orifice into two, right and left, and so the communication between the two auricles is closed. Prior to this closure, however, the septum primum at its upper and back part becomes disconnected with the auricular wall ; an opening, called the *foramen ovale*, is formed ; and the septum primum constitutes what is called the *valve of the foramen ovale*. Another septum, known as the **septum secundum,** grows from the upper and back part of the auricle, at a point to the right of the original attachment of the septum primum, in a direction downwards and forwards over the foramen ovale. The septum secundum gradually closes the foramen ovale, and gives rise to the *annulus ovalis*, or *limbus Vieussenii*, and the portion of the auricular septum above it.

The **aortic bulb** becomes divided into the ascending aorta and the trunk of the pulmonary artery. For this purpose the endocardial lining becomes thickened, and forms two longitudinal folds, which are placed opposite each other. These folds grow towards the centre of the aortic bulb, where they meet and fuse to form a septum, and in this manner the cavity of the bulb is divided into the two vascular tubes just mentioned. In the lower part of the aortic bulb the two folds are disposed *laterally*, right and left, which accounts for the pulmonary artery and the ascending aorta being at first placed anteriorly and posteriorly respectively. In the upper part of the aortic bulb, however, the two folds are disposed one *in front*, and the other *behind ;* hence the lateral positions of the ascending aorta and the trunk of the pulmonary artery a little above their roots. Two grooves make their appearance on the exterior of the aortic bulb, which correspond in position with the longitudinal folds in the interior, and, as these grooves deepen, the bulb becomes separated into two distinct vessels.

The septum of the aortic bulb, as stated, grows downwards to join the interventricular septum, and, when the union is effected, the division of the ventricular portion of the heart into two ventricles is complete. Thereafter the right ventricle communicates wtih the pulmonary artery, and the left ventricle with the ascending aorta.

Peculiarities of the Fœtal Circulation. — The structures peculiar to the fœtus in connection with the circulation of the blood are as follows :

1. Foramen ovale.
2. Eustachian valve.
3. Ductus arteriosus.
4. Hypogastric and umbilical arteries.
5. Umbilical vein.
6. Ductus venosus.

The **foramen ovale** is an oval opening in the interauricular septum. Up to the fourth month of intra-uterine life it is quite free, but after that period the *valve of the foramen ovale* gradually extends upwards on the left side of, and beyond, the annulus ovalis, and acts as a valve during the latter months of fœtal life. The blood can then

only flow from the right auricle into the left, its return being prevented by this valve.

The **Eustachian valve** is of large size during fœtal life, and is associated with the orifice of the inferior vena cava at the postero-inferior angle of the right auricle. It is a crescentic fold of the endocardium, which extends between the anterior margin of the orifice of the inferior vena cava and the anterior horn of the annulus ovalis. Its situation is such as to direct the blood entering the right auricle by the inferior vena cava to the foramen ovale.

The **ductus arteriosus** connects the trunk of the pulmonary artery to the arch of the aorta at a point immediately beyond the origin of the left subclavian artery, and it conveys the most of the blood from the right ventricle to the descending thoracic aorta.

The **hypogastric arteries,** right and left, are prolonged from the common iliac arteries to the umbilicus, through which they leave the body of the fœtus, and, under the name of the **umbilical arteries,** they pass along the umbilical cord to be distributed to the fœtal part of the placenta. They convey the impure blood of the fœtus to the placenta.

The **umbilical vein** extends from the fœtal part of the placenta through the umbilicus to the inferior surface of the liver, where it traverses the umbilical fissure, and gives off right and left branches to the right and left lobes, which join the branches of the vena portæ. After parting with its right and left branches the umbilical vein is prolonged, under the name of the **ductus venosus,** to the inferior vena cava, which it joins at the caval fossa of the liver. The umbilical vein conveys pure blood from the placenta into the body of the fœtus.

Fœtal Circulation.—The right auricle receives blood from the superior and inferior venæ cavæ, and from the coronary sinus. The superior vena cava returns the venous blood from the head and neck, the upper limbs, and the thoracic portion of the trunk; and the inferior vena cava returns the blood from the lower limbs, the abdominal portion of the trunk, and the placenta. The placental blood is pure, and reaches the inferior vena cava in two ways: (1) a large quantity of it is conveyed directly into the inferior vena cava by the ductus venosus; and (2) some of it circulates through the liver in the branches of the vena portæ, and is thereafter conveyed to the inferior vena cava by the hepatic veins. The blood entering the right auricle by the inferior vena cava is necessarily of a mixed nature, being partly placental and partly venous.

The impure blood which enters the right auricle by the superior vena cava, having received a small quantity of the mixed blood which enters by the inferior vena cava, passes through the right auriculo-ventricular orifice into the right ventricle, and from thence is driven into the trunk of the pulmonary artery. A small quantity of it is conveyed to the lungs by the right and left pulmonary arteries, which at this period are of small size, and it is

returned from the lungs to the left auricle by the pulmonary veins. By far the greater part of the right ventricular blood, however, enters the ductus arteriosus, and is conveyed by it to the aorta immediately *beyond* the origin of the left subclavian artery. None of this blood, therefore, enters the three great vessels which spring from the arch of the aorta. The whole of it descends in the descending thoracic and abdominal portions of the aorta, and has a

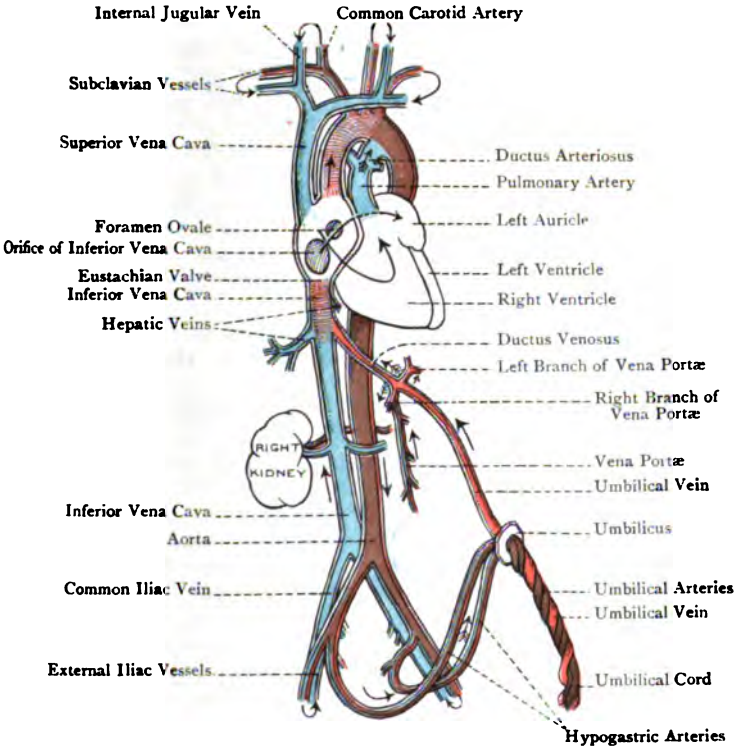


FIG. 398.—DIAGRAM OF THE ORGANS OF CIRCULATION IN THE FŒTUS

(The arrows indicate the course of the Circulation).

twofold destination. Part of it is distributed to the abdominal and pelvic viscera, and the lower limbs, whence it is returned by the vena portæ and inferior vena cava ; but the greater part of it is conveyed out of the body of the fœtus to the placenta by means of the hypogastric and umbilical arteries. Having been purified in the placenta, it is returned thence by the umbilical vein into the body of the fœtus. This placental blood, as stated, reaches the inferior vena cava in two ways, partly directly by means of the

ductus venosus, and partly indirectly by means of the hepatic veins after having circulated through the liver.

A small quantity of the mixed blood which enters the right auricle by the inferior vena cava mingles with the venous blood which enters that cavity by the superior vena cava; but by far the greater part of it is directed by the Eustachian valve to the foramen ovale, through which it passes into the left ventricle. Here it receives the blood which has been returned from the lungs by the pulmonary veins, and then it passes through the left auriculo-ventricular orifice into the left ventricle. From the left ventricle it is driven into the aorta, and the greater part of it passes into the innominate, left common carotid, and left subclavian arteries to be distributed to the brain, head and neck, and upper limbs, as well as to the substance of the heart by the coronary arteries. A small quantity, however, of this mixed blood passes into the descending thoracic aorta, and mixes with the venous blood entering by the ductus arteriosus. The blood is returned to the right auricle of the heart from the brain, head and neck, and upper limbs, by the superior vena cava, and from the substance of the heart by the coronary sinus.

Changes at Birth.—At birth respiration is established, and the lungs perform their respiratory function; the right and left pulmonary arteries undergo rapid enlargement; and the placental circulation is entirely arrested. The **hypogastric arteries** become obliterated and transformed into fibrous cords, except at their roots, where they persist as the *internal iliac arteries*. The **umbilical vein** becomes obliterated, and is now known as the *round ligament of the liver*. The **ductus venosus** becomes transformed into a fibrous cord, called the *ligamentum ductûs venosi*, which occupies the venosal fissure of the liver. The **foramen ovale** is closed by the *valve of the foramen ovale* becoming adherent to the margin of the *annulus ovalis* or *limbus Vieussenii* on its left side. In some cases, however, this union is incomplete, and a minute opening persists, through which a small probe may be passed. In very rare cases a fairly large opening may remain, as in the condition known as *morbus cæruleus*. As viewed from the interior of the left auricle, the upper crescentic border of the valve of the foramen ovale is visible upon the interauricular septum, and above this border there is a slight depression. The **ductus arteriosus** becomes obliterated, and persists as a fibrous cord, called the *ligamentum ductûs arteriosi*, which passes from the root of the left pulmonary artery to the arch of the aorta immediately *beyond* the origin of the left subclavian artery.

The closure of all the peculiar structures associated with the fœtal circulation is usually complete from the eighth to the tenth day after birth.

Development of the Principal Arteries.—In the embryo the aortic bulb or bulbus arteriosus divides into two vessels, called the **primitive ventral aortæ**, which pass forwards on the ventral aspect of the fore-gut. From each of

these vessels two arterial arches are given off, and from the aortic bulb four arches are given off, on either side, which arise by a common stem. Subsequently two of these four arches arise directly from each ventral aorta, and two maintain their connection with the aortic bulb. There are thus **six arterial arches** on each side, four of which spring from the corresponding ventral aorta, and two from the aortic bulb. They are named first, second, third, fourth, fifth, and sixth, in this order from before backwards, and they enter the corresponding visceral arches. The arterial arches are continued into the **two primitive dorsal aortæ,** each dorsal aorta being continuous with the ventral aorta through means of the first arterial arch. The primitive dorsal aortæ pass backwards on either side of the notochord, and they terminate at first in the two allantoic arteries, which convey the blood to the allantois. Subsequently the dorsal aortæ unite, about the level of the fourth thoracic vertebra, to form one vessel—the dorsal aorta.

The **arterial arches,** as stated, are first, second, third, fourth, fifth, and sixth, from before backwards. As development proceeds, important changes take place during the formation of the principal vessels. The first, second, and fifth arches on each side disappear, and so also does the sixth right arch. The part of the left dorsal aorta between the third and fourth left arches disappears, and so also does the part of the right dorsal aorta which extends from the third right arch to the place of junction of the two dorsal aortæ.

The sixth left arch at its commencement gives rise to the terminal portion of the trunk of the pulmonary artery. It then furnishes the right and left pulmonary arteries, and beyond this point it gives rise to the ductus arteriosus, which joins the left dorsal aorta. The root of the left ventral aorta forms the part of the arch of the aorta between the innominate and left common carotid arteries. The fourth left arch forms the part of the arch of the aorta between the left common carotid artery and the point of entrance of the ductus arteriosus. The part of the left dorsal aorta between the fourth left arch and the place of junction of the two dorsal aortæ forms the commencement of the descending aorta. The root of the right ventral aorta gives rise to the innominate artery. The fourth right arch forms the *first* part of the right subclavian artery as far as the origin of the internal mammary artery. The part of each ventral aorta between the third and fourth arches forms the corresponding common carotid artery. The third arch and the part of the dorsal aorta above it persist as the *internal* carotid artery, whilst the part of the ventral aorta above the third arch forms the *external* carotid artery.

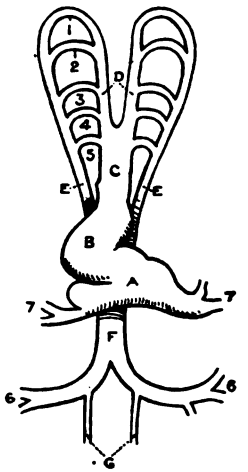


FIG. 399.—DIAGRAM OF THE HEART AND PRIMITIVE VESSELS OF THE EMBRYO CHICK, AS SEEN FROM BELOW AND ENLARGED (AFTER ALLEN THOMSON, IN QUAIN'S 'EMBRYOLOGY').

A, Auricle; B, Ventricle; C, Bulbus Arteriosus; D, Primitive Ventral Aortæ; E, E, Primitive Dorsal Aortæ; F, Single Dorsal Aorta; G, Continuations of the Dorsal Aortæ beyond the origins of the Vitelline Arteries; 1 to 5, Aortic Arches; 6, 6, Vitelline Arteries; 7, 7, Vitelline Veins.

In the foregoing statement of the development of the principal arteries the left subclavian has been left out of account, because it is developed from a segmental artery.

Summary—Ventral Aortæ—*Right Ventral Aorta.*—The root, that is, the part as high as the fourth right arch, forms the innominate artery; the part between the fourth and third arches forms the right common carotid

artery ; and the part above the third arch forms the right external carotid artery. *Left Ventral Aorta.*—The root, that is, the part as high as the fourth left arch, forms the part of the arch of the aorta between the innominate and left common carotid arteries ; and the part above the fourth left arch acts as on the right side.

Dorsal Aortæ—*Right Dorsal Aorta.*—The part between the third right arch and the place of junction of the two dorsal aortæ disappears ; the part above the third arch persists as part of the right internal carotid artery. *Left Dorsal Aorta.*—The part between the third and fourth left arches disappears ; the part above the third arch persists as part of the left internal carotid artery. The part between the fourth arch and the place of junction of the two dorsal aortæ forms the commencement of the descending aorta.

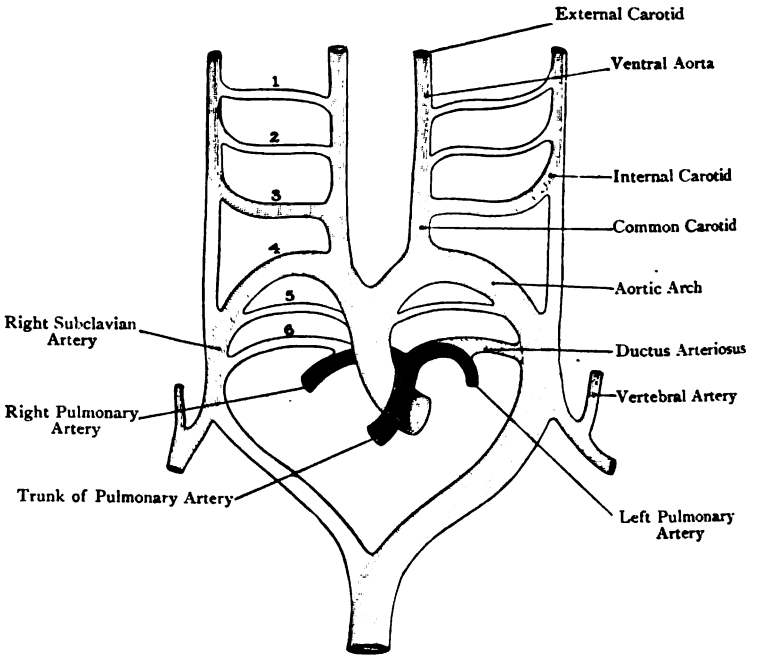


FIG. 400.—SCHEME OF THE AORTIC ARCHES AND THEIR DESTINATION (MODIFIED FROM KOLLMANN) (FROM GRAY'S 'ANATOMY').

Arterial Arches.—The first, second, and fifth arches, on each side, and the sixth right arch disappear. The sixth left arch forms (1) a small portion of the trunk of the pulmonary artery at its termination, (2) the right and left pulmonary arteries, and (3) the ductus arteriosus. The fourth right arch forms the first part of the right subclavian artery as far as the origin of the internal mammary artery. The fourth left arch forms the part of the arch of the aorta between the left common carotid artery and the point of entrance of the ductus arteriosus. The third arch on each side persists as part of the corresponding internal carotid artery.

Summary of the Permanent Aorta.—The ascending aorta is developed from the arterial bulb, in conjunction with the greater part of the trunk of the pulmonary artery. The part of the arch of the aorta between the innominate

and left common carotid arteries is developed from the root of the left ventral aorta, and the part of the arch between the left common carotid artery and the place of entrance of the ductus arteriosus is developed from the fourth left arterial arch. The descending aorta is formed superiorly by a portion of the left dorsal aorta, but for the most part by the fusion of the right and left dorsal aortæ.

According to some authorities, there are only five arterial arches on either side. To adapt this view to the foregoing description, the fifth arch of these authorities is to be regarded as representing the sixth arch just described.

Development of the Veins.—The **primitive veins** are (1) the two primitive jugular veins, right and left, which return the blood from the cranial cavity of the embryo; (2) the two cardinal veins, right and left, which return the blood from the walls of the trunk and the Wolffian bodies; (3) the two vitelline or omphalo-mesenteric veins, right and left, which return the blood from the vascular area on the yolk-sac; and (4) the umbilical veins, which at first are two in number, right and left, and return the blood from the placenta.

Primitive Jugular Veins.—The primitive jugular vein of each side returns the blood from the cranial cavity, and for the most part it gives rise to the *external* jugular vein. Near its lower extremity it is joined at a later period by the internal jugular and subclavian veins. The primitive jugular vein joins the cardinal vein, which ascends from the trunk, and so the **duct of Cuvier** of that side is formed. The ducts of Cuvier, right and left, represent the primitive right and left superior venæ cavæ, and they open into the sinus venosus of the embryonic heart, one on either side. At first they occupy a transverse position, the heart at this period being situated in the neck. As, however, the heart descends into the thorax, each duct of Cuvier passes downwards in line with the corresponding primitive jugular vein. A cross communicating branch, called the **transverse jugular vein,** is now formed, which passes obliquely between the lower ends of the primitive jugular veins, in each case a little below the point where the subclavian and internal jugular veins join it, but lower on the right side than on the left. The greater part of the *left* innominate vein is developed from this transverse jugular vein, whilst the *right* innominate vein is formed from the short portion of the right primitive jugular vein which intervenes between the point where it receives the right subclavian and internal jugular veins and the point where it is joined by the transverse jugular vein. The portion of the right primitive jugular vein immediately below the point where it is joined by the transverse jugular vein forms the *upper* part of the permanent superior vena cava, that is, the part above the point where the right azygos vein opens into it. The *lower* part of the superior vena cava is developed from the *right* duct of Cuvier. The portion of the left primitive jugular vein between the point where it receives the left subclavian and internal jugular veins and the commencement of the transverse jugular vein forms a small part of the left innominate vein; and the portion below and adjacent to the commencement of the transverse jugular vein forms the upper part of the left superior intercostal vein, thus accounting for the ending of that vein in the left innominate vein. The *left* duct of Cuvier becomes obliterated, but the following traces of it persist in the adult: (1) the coronary sinus, (2) the oblique vein of Marshall, and (3) a delicate fibrous cord, contained within a small triangular fold of the serous portion of the pericardium in front of the root of the left lung, known as the vestigial fold of Marshall.

It is right to state that the primitive jugular vein of each side is regarded by some authorities as forming the permanent *internal* jugular vein, and not the external jugular, this latter being of later development.

Cardinal Veins.—These, as stated, are two in number, right and left, and they return the blood from the walls of the trunk and the Wolffian bodies. The *lower part* of each vein receives the sciatic vein, which is the primitive vein of the lower limb, and this lower part of the cardinal vein persists as the *internal* iliac vein. A little above this point it receives, at a later period, the external iliac vein. A communicating vessel, called the **transverse iliac**

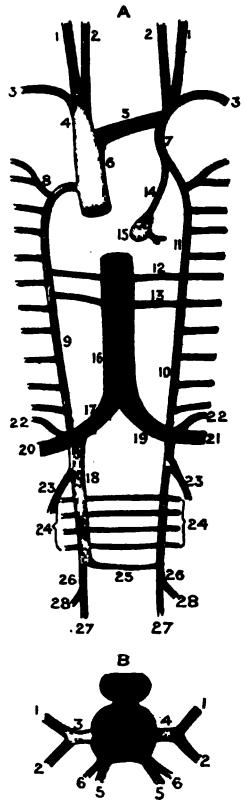


FIG. 401.

A, SCHEME OF THE DEVELOPMENT OF THE PRINCIPAL VEINS.
B, SCHEME OF THE PRIMITIVE VEINS WHICH OPEN INTO THE PRIMITIVE HEART.

A

1. External Jugular Vein (Primitive Jugular)
2. Internal Jugular Vein
3. Subclavian Vein
4. Right Innominate Vein
5. Left Innominate Vein
6. Superior Vena Cava
7. Left Superior Intercostal Vein
8. Right Superior Intercostal Vein
9. Right Azygos Vein
10. Lower Left Azygos Vein
11. Upper Left Azygos Vein
12, 13. Transverse Azygos Veins
14. Left Duct of Cuvier (Remains of)
15. Coronary Sinus
16. Inferior Vena Cava
17, 18. Inferior Vena Cava
19. Mesial Part of Left Renal Vein
20. Right Renal Vein
21. Lateral Part of Left Renal Vein
22. Suprarenal Vein
23. Spermatic Vein (Ovarian Vein)
24. Lumbar Veins
25. Transverse Iliac Vein
26. Common Iliac Vein
27. Internal Iliac Vein
28. External Iliac Vein

B

1, 1. Primitive Jugular Veins
2, 2. Cardinal Veins
3. Right Duct of Cuvier
4. Left Duct of Cuvier
5, 5. Vitelline Veins
6, 6. Umbilical Veins

vein, is developed, which extends obliquely from the left cardinal vein a little above the point where it receives the external iliac vein to the right cardinal vein, joining it at a higher level. In its subsequent course each cardinal vein receives veins from the Wolffian body and the walls of the trunk, and in the thoracic region the veins become connected by two transverse branches, upper and lower. Finally, each cardinal vein joins the corresponding primitive jugular vein to form the duct of Cuvier. After the development of the kidney, the renal vein is a tributary of the corresponding cardinal vein. The lower part of the cardinal vein forms, as stated, the internal iliac vein. The transverse iliac vein forms the greater part of the *left* common iliac vein, the first portion of that vessel being developed from that part of the left cardinal vein which intervenes between the termination of the left external iliac vein and the commencement of the transverse iliac vein. The portion of the right cardinal vein which intervenes between the termination of the right external iliac vein and the right extremity of the transverse iliac vein forms the *right* common iliac vein. The portion of the left cardinal vein between the transverse iliac vein and a point a little below the left renal vein becomes obliterated. The portion of it immediately below the left renal vein, which portion receives the left spermatic vein, persists and forms the upper part of the left spermatic vein, thus accounting for the mode of termination of that vein in the adult. The left cardinal vein may again become obliterated for a short distance above the left renal vein, and thereafter its upper or thoracic portion persists as the lower left azygos vein, the upper left azygos vein, and the lower part of the left superior intercostal vein. The portion of the left cardinal vein between the lower and upper left azygos veins, and also the portion between the upper left azygos vein and the left superior intercostal vein, may, or may not, undergo obliteration. The portion of the right cardinal vein between the right extremity of the transverse iliac vein and the right renal vein persists as the *lower part* of the inferior vena cava, and it receives superiorly the *right* spermatic vein, which accounts for the mode of termination of that vein in the adult. The right cardinal vein may become obliterated for a short distance above the right renal vein, and thereafter its upper thoracic portion persists as the right azygos vein, which receives the right superior intercostal vein. The lower transverse communicating branch between the cardinal veins in the thorax persists as the lower transverse azygos vein, and the upper transverse branch persists as the upper transverse azygos vein.

Vitelline or **Omphalo-mesenteric Veins.**—These, as stated, are two in number, right and left. They return the blood from the vascular area on the yolk-sac, and enter the cœlom or body-cavity of the embryo along the vitelline duct. They are the first veins to become developed, and they give rise to the portal and hepatic veins. Within the body-cavity the vitelline veins open into the sinus venosus of the primitive heart. The sinus venosus also receives, near the vitelline veins, the two umbilical veins, right and left, which return the blood from the placenta. In addition, it receives the right and left ducts of Cuvier, or primitive superior venæ cavæ, which open into it one on either side. The vitelline veins, after entering the body-cavity, arrange themselves one on either side of the primitive duodenum. In this situation three transverse connections are formed between them, two being in front of the gut, upper and lower, and one behind it. In this manner the duodenum is embraced by two venous rings, placed one above the other. The lower connection between the vitelline veins amounts to a fusion of the two vessels for a short distance, and this united portion, which receives veins from the intestinal tube and stomach, forms the *lower* part of the vena portæ. The *upper* part of that vessel is formed by the *left* half of the lower venous ring and the *right* half of the upper one, the other halves of these rings undergoing obliteration. The vitelline veins having ceased to be connected with the sinus venosus, the portions of them above the upper duodenal ring break up into a network of vessels within the liver, which is now being developed, the vessels in the centre of the network being of a capillary nature. The veins which carry the blood to these capillaries are called the *venæ advehentes*,

and they represent the right and left divisions of the vena portæ. The vessels which pass from the capillaries to the sinus venosus are called the *venæ revehentes*, and they form the hepatic veins.

Umbilical Veins.—These veins persist as two vessels, right and left, for some time, and, as stated, they open into the sinus venosus. Subsequently they cease to be connected with that sinus, and a communication becomes established between the left umbilical vein and the upper venous duodenal ring. The right umbilical vein becomes obliterated, and the left vein undergoes enlargement. At first its blood circulates entirely through the capillaries of the liver. At a later stage, however, a branch is formed which extends from the upper venous duodenal ring to the right hepatic vein near its entrance into the sinus venosus. This branch represents the **ductus venosus,** and it conveys placental blood to the sinus venosus without any of this blood having to circulate through the liver. Subsequently the left hepatic vein, having

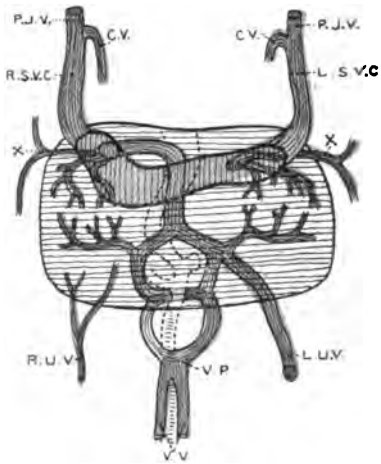


FIG. 402.—THE VENOUS TRUNKS OF THE HUMAN EMBRYO (HIS).

P.J.V. Primitive Jugular Vein
C.V. Cardinal Vein
R.S.V.C. Right Superior Vena Cava
L.S.V.C. Left Superior Vena Cava
X.X. Upper separated portions of Umbilical Veins
R.U.V. Right Umbilical Vein
L.U.V. Left Umbilical Vein
V.P. Vena Portæ
V.V. Vitelline Veins

ceased to be connected directly with the sinus venosus, forms a communication with the upper end of the ductus venosus, which end is connected with the inferior vena cava.

Development of the Inferior Vena Cava.—This vessel makes its appearance later than the preceding veins. It commences at the cardiac end of the ductus venosus, and from this point it is developed in a downward direction in front of the aorta. Having reached the interval between the kidneys, it divides into two branches, right and left, each of which joins the corresponding cardinal vein on a level with the renal vein. The portion of the cardinal vein immediately above the junction may disappear, or it may persist, and so establish a connection between the azygos vein and the inferior vena cava. or the renal vein. The primitive inferior vena cava and its *right division* persist as the *upper part* of the permanent inferior vena cava. The portion of the right cardinal vein between the right renal vein above and the point of entrance of the transverse iliac vein below persists, and forms the *lower*

part of the permanent inferior vena cava, which is thus usually placed on the right side of the vertebral column. The *left division* of the primitive inferior vena cava persists, and forms the *mesial part of* the left renal vein. The explanation of the occasional presence of a permanent inferior vena cava on the left side of the vertebral column, instead of on the right side, will be readily understood.

Trachea in the Thorax.—The thoracic portion of the trachea extends from the level of the upper border of the manubrium sterni to the level of the intervertebral disc between the bodies of the fourth and fifth thoracic vertebræ, where it divides into the two bronchi, right and left. It occupies a median position in the superior mediastinum, and its length is about 2½ inches. As in the neck, it is cylindrical and firm in front and at the sides, but posteriorly it is flattened and membranous, where it rests upon the œsophagus.

Relations—*Anterior.*—The manubrium sterni, and the origins of the sterno-hyoid and sterno-thyroid muscles; the remains of the thymus body; the origins of the innominate and left common carotid arteries, and the left innominate vein; and the arch of the aorta, which lies upon it immediately above its bifurcation into the two bronchi, with the intervention of the deep cardiac plexus of nerves. *Posterior.*—The œsophagus, which inclines partially to the left of the trachea. *Right.*—The right pneumogastric nerve; the innominate artery, after it has left the front of the trachea; and the right pleural sac. *Left.*—The arch of the aorta and the left common carotid artery, after these have left the front of the trachea; the left subclavian artery; and the left recurrent laryngeal nerve.

Bronchi.—The bronchi, right and left, commence at the bifurcation of the trachea, and each passes to the hilum of the corresponding lung, where its ramifications commence. As in the trachea, each bronchus is cylindrical and firm in front and at the sides, but posteriorly it is flattened and membranous. There being certain differences between the bronchi, a separate description is required for each.

The **right bronchus** is about 1 inch in length up to the point where it gives off its first, or eparterial, branch. It has about six cartilaginous rings, and is larger than the left bronchus. It is more vertical than the left bronchus, and therefore coincides with the direction of the trachea to a greater extent than its fellow.

Relations—*Superior.*—The right azygos vein arches over it to open into the superior vena cava. *Posterior.*—The right pneumogastric nerve. *Inferior.*—The right pulmonary artery, which subsequently lies *anterior* to it.

About 1 inch from its commencement the right bronchus gives off a branch from its outer side which passes to the upper lobe of the right lung. This branch is known as the *eparterial bronchus*, because it arises above the right pulmonary artery. The rest of the right bronchus is spoken of as being *hyparterial.*

The **left bronchus** is about 2 inches in length. It has about twelve cartilaginous rings, and is smaller than the right bronchus on account of the smaller size of the left lung. Its course is more oblique than that of its fellow, and it is directed downwards and outwards beneath the arch of the aorta to the hilum of the left lung.

Relations—*Anterior.*—The left pulmonary artery, which subsequently lies *above* it. *Posterior.*—The œsophagus and the descending thoracic aorta.

The left bronchus has no eparterial branch.

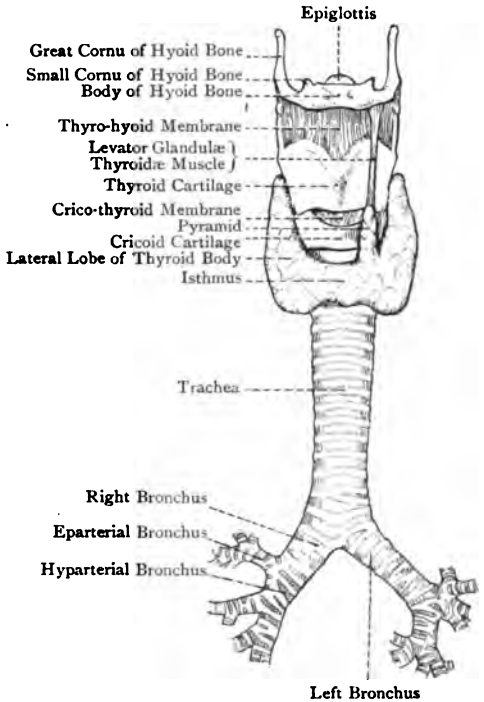


FIG. 403.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (ANTERIOR VIEW).

When the interior of the trachea is viewed from above, as in using the laryngoscope, the openings of the two bronchi are seen to be separated by a ridge which is situated to the left of the median line, and more of the interior of the right bronchus than of the left is visible. Partly on this account, and partly by reason of the more vertical direction of the right bronchus, as well as its larger size, a foreign body getting into the trachea is more apt to descend into the *right* bronchus than into the left.

The structure of the trachea will be described in connection with the description of the windpipe in the neck.

Œsophagus in the Thorax.—The œsophagus or gullet extends from the pharynx to the stomach. In the first part of its course it lies in the neck, and this portion will be found described in connection with that region. The **thoracic part** (see Fig. 405) extends from the level of the upper border of the manubrium sterni to the level of the body of the twelfth thoracic vertebra, where it passes through the œsophageal opening of the diaphragm, and terminates at the cardiac orifice of the stomach. Its course is not quite vertical. At its commencement the thoracic portion lies partially to the left of the middle line, but as it descends it comes to occupy a median position about the level of the fifth thoracic vertebra, and inferiorly it again inclines partially to the left. It occupies the superior and posterior mediastinal spaces, and lies in front of the vertebral column, accurately following the thoracic antero-posterior curve.

Relations—*Anterior.*—The trachea as low as the intervertebral disc between the bodies of the fourth and fifth thoracic vertebræ; the root of the left bronchus; the posterior wall of the pericardium, opposite the back of the left auricle of the heart; and the vertebral portion of the diaphragm. *Posterior.*—The vertebral column; the longus colli muscles, especially the left; the thoracic duct and right azygos vein; the right aortic intercostal arteries; the upper and lower transverse azygos veins; and, inferiorly, the descending aorta. *Right.*—The right posterior mediastinal pleura. *Left.*—The thoracic portion of the left subclavian artery; the upper part of the thoracic duct; the left posterior mediastinal pleura; and the descending aorta, except inferiorly.

The right and left pneumogastric nerves are intimately related to the œsophagus. They are at first disposed laterally, and their branches give rise to the *plexus gulæ*. Subsequently the right pneumogastric nerve descends on the posterior surface of the œsophagus, and the left on the anterior surface, in which positions they accompany the gullet through the œsophageal opening of the diaphragm.

Blood-supply—Arteries.—These are (1) the œsophageal branches of the descending aorta, (2) the œsophageal branches of the gastric artery from the cœliac axis, and (3) twigs from the left inferior phrenic artery. In the neck the œsophagus receives branches from the right and left inferior thyroid arteries.

The **veins** accompany the corresponding arteries, and terminate in the right azygos vein and the two left azygos veins.

Lymphatics.—These pass to the posterior mediastinal glands.

Nerves.—These are derived from the pneumogastric and sympathetic nerves.

Structure.—The wall of the œsophagus consists of three coats, namely, muscular, submucous, and mucous.

The **muscular coat** is thick, and is disposed in two layers, an external longitudinal, and an internal circular.

The *longitudinal muscular fibres* are attached superiorly to the upper part of the median ridge on the posterior surface of the cricoid cartilage, and from this point they descend as two flattened bands, one on either side of the tube. These expand and soon meet, giving rise to one continuous layer which completely surrounds the gullet. Inferiorly they are continuous with the longitudinal muscular fibres of the stomach. Accessory fleshy slips are described as passing from this layer to the back of the trachea, the back of the root of the left bronchus, the pericardium, and the left pleura.

The *circular muscular fibres* are continuous superiorly with the lower fibres of the inferior constrictor muscles of the pharynx, and inferiorly with the circular, and also with the oblique, muscular fibres of the stomach.

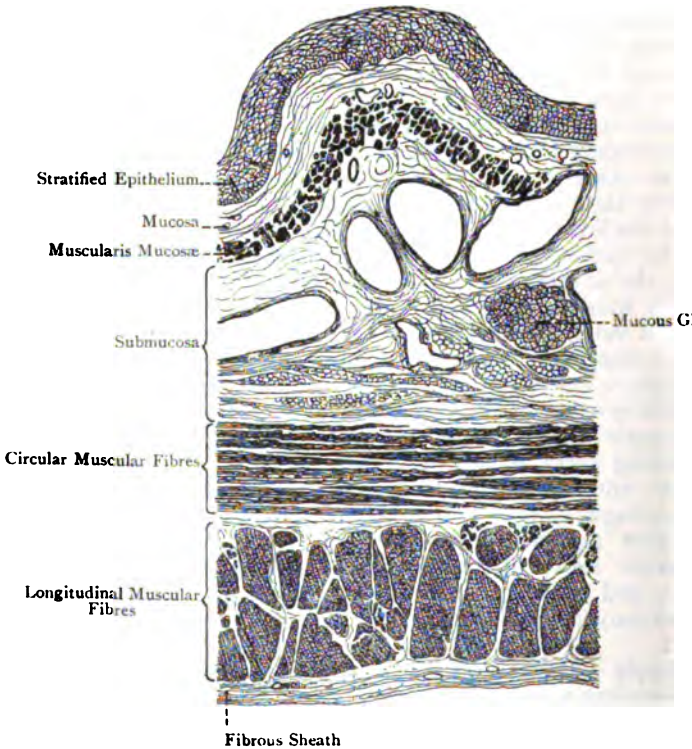


FIG. 404.—TRANSVERSE SECTION OF THE WALL OF THE ŒSOPHAGUS.

The muscular tissue of the œsophagus is of the striated variety over about the *upper third* of the tube, but elsewhere it is of the plain or non-striated variety.

The **submucous coat** consists of loose areolar tissue, which contains the larger bloodvessels and the mucous glands.

The **mucous coat** is thick, and is thrown into longitudinal folds, on account of the loose disposition of the submucous coat. The portion of it next the submucous coat consists of plain muscular fibres, which are arranged longitudinally. This portion is known as the *muscularis mucosæ*, and it is best marked in the lower part of the gullet. The inner surface of the mucous

coat is provided with numerous papillæ, and it is covered by stratified squamous epithelium, which is thrown into elevations by the papillæ.

The *mucous glands* are racemose, and are situated in the submucous coat. Their ducts are large and long, and on their way to the free surface some of them traverse small collections of lymphoid tissue.

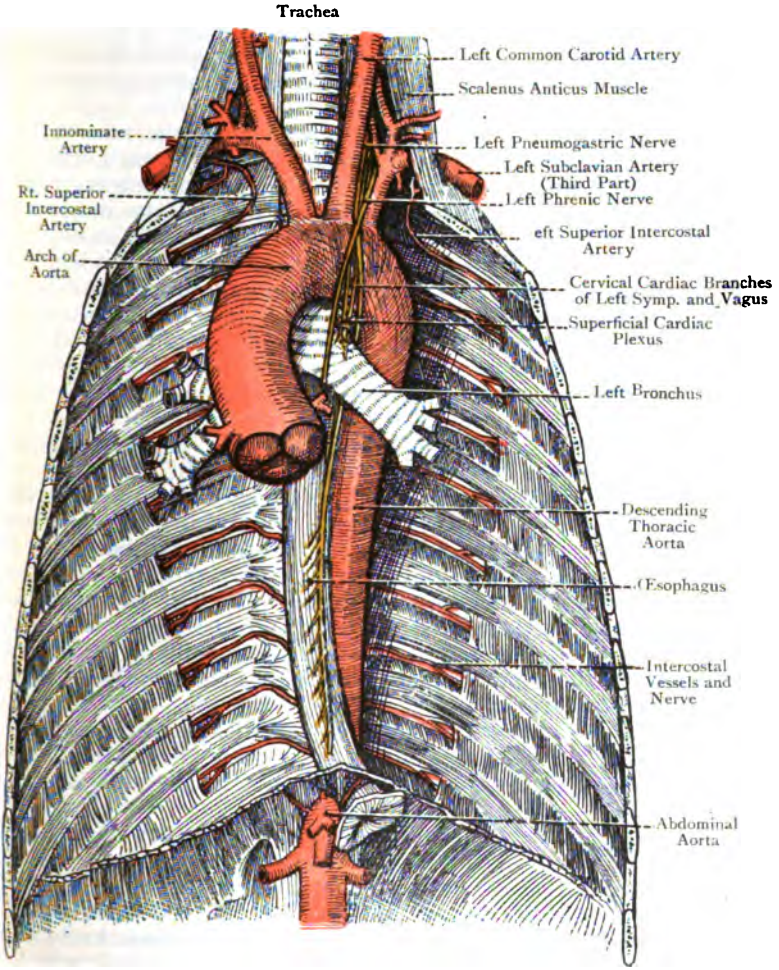


FIG. 405.—DISSECTION OF THE POSTERIOR WALL OF THE THORAX.

Development.—The œsophagus is developed from that part of the fore-gut which succeeds to the portion from which the pharynx is developed. At first it is very short, on account of the imperfect development of the neck. As, however, the neck becomes formed, and as the stomach descends, the œsophagus becomes elongated.

Descending Aorta.—The descending aorta, which is the continuation of the aortic arch, commences on the left side of the body of the fourth thoracic vertebra on a level with its lower border, and it terminates at the lower border of the body of the twelfth thoracic vertebra. At the latter level it passes through the aortic opening of the diaphragm, and enters upon the abdominal part of its course. The vessel lies in the posterior mediastinum, and its course is downwards and inwards, so that, though at first on the left side of the vertebral column, it subsequently takes up a position in front of it.

Relations—*Anterior.*—From above downwards, the root of the left lung; the pericardium; the œsophagus; and the vertebral portion of the diaphragm. *Posterior.*—The bodies and intervertebral discs of thoracic vertebræ below the fourth; and the upper and lower transverse azygos veins. *Right.*—The œsophagus, superiorly; the thoracic duct; and the right azygos vein. *Left.*—The left posterior mediastinal pleura; and the upper and lower left azygos veins. Inferiorly the œsophagus inclines slightly to the left of the vessel. It is to be noted that the œsophagus has a threefold relation to the descending aorta. At first it lies upon the right side of the vessel; then directly in front of it; and finally it inclines slightly to its left side.

Branches.—These are as follows: bronchial, pericardial, œsophageal, posterior mediastinal, intercostal, and subcostal.

The *bronchial arteries* supply the lungs and the bronchial lymphatic glands. They are usually three in number—one right and two left. The *right* bronchial artery arises from the aorta in common with the upper left bronchial artery, or sometimes from the first right aortic intercostal artery. The *two left* bronchial arteries, upper and lower, arise directly from the aorta, near each other. The arteries enter the respective lungs behind the bronchi, and in their further course and distribution they follow the ramifications of the bronchial tubes.

The *bronchial veins* accompany the corresponding arteries. The *right* vein opens into the right azygos vein; and the *left* vein opens either into the upper left azygos vein, or into the left superior intercostal vein.

The *pericardial branches* supply the posterior part of the pericardium.

The *œsophageal branches* are numerous, and arise at irregular intervals. Superiorly they spring from the right side of the aorta, and inferiorly from its anterior wall. They anastomose freely with one another along the wall of the œsophagus; superiorly with the œsophageal branches of the inferior thyroid arteries; and inferiorly with the œsophageal branches of the gastric artery from the cœliac axis, the latter branches entering the thorax through the œsophageal opening of the diaphragm.

The *posterior mediastinal branches* are very minute, and supply the lymphatic glands and areolar tissue in the posterior mediastinum.

The **intercostal arteries** are arranged in pairs, and are nine in number on each side. They are destined for the lower nine intercostal spaces, the first two spaces being supplied by the superior intercostal artery, which is a branch of the second part of the subclavian on the right side, and of the first part on the left side. They arise in pairs from the posterior wall of the descending aorta, and they pass outwards upon the bodies of the vertebræ to the posterior extremities of the intercostal spaces. The arteries of the right side pass behind the œsophagus, the thoracic duct, and the right azygos vein; and those of the left side pass behind the upper and lower left azygos veins, according to their level. The arteries of both sides pass behind the gangliated cord of the sympathetic. The upper right intercostal arteries are longer than those of the left side, on account of the position of the descending aorta on the left side of the vertebral column. All the arteries lie behind the parietal pleura. Each artery, on entering an intercostal space, lies at first between the parietal pleura and the posterior intercostal aponeurosis. Its course is outwards and slightly upwards, and partly on this latter account, but chiefly on account of the downward slope of the rib, it soon gains the lower border of the upper rib. At a point corresponding to the angle of the rib the artery pierces the posterior intercostal aponeurosis, and, passing between the external and internal intercostal muscles, it enters the subcostal groove of the upper rib. In this position it courses forwards, and ends by anastomosing with the upper anterior intercostal branch of the internal mammary artery, or of its musculo-phrenic branch, according to the level.

The companion intercostal vein lies above the artery, and the corresponding intercostal nerve lies below it. The order of structures, therefore, in the subcostal groove, from above downwards, is as follows: intercostal vein, intercostal artery, and intercostal nerve. The upper seven aortic intercostal arteries are confined to the intercostal spaces which they occupy; but the lower two, namely, those in the tenth and eleventh intercostal spaces, ultimately leave these spaces, and pass into the abdominal wall, where they have been described in connection with the abdomen.

Branches.—These are dorsal, giving off a spinal branch; collateral; and lateral cutaneous.

The *dorsal branch* arises from the aortic intercostal artery as that vessel enters the posterior extremity of an intercostal space. It passes backwards, in company with the posterior primary division of the corresponding spinal nerve, between the adjacent transverse processes, where it lies internal to the superior costo-transverse ligament. Opposite the intervertebral foramen it gives off its *spinal branch*, which enters the spinal canal through the foramen to be distributed to its osseous and ligamentous walls, as well as to the spinal cord and its membranes. The dorsal branch, continuing its course backwards, divides into an internal and external branch, which supply the muscles and integument of the back.

The *collateral intercostal artery* arises from the main aortic intercostal opposite the angle of the rib. It passes obliquely downwards and outwards to the upper border of the lower rib, along which it courses, lying between the external and internal intercostal muscles. Anteriorly it ends by anastomosing with the lower anterior intercostal branch of the internal mammary artery, or of its musculophrenic branch, according to the level.

The *lateral cutaneous branches* accompany the lateral cutaneous branches of the corresponding intercostal nerves to the integument.

The *first* aortic intercostal artery, namely, that which lies in the *third* intercostal space, furnishes a branch, of variable size, which ascends over the neck of the third rib to the second intercostal space. This branch anastomoses with the second intercostal artery, which is a branch of the superior intercostal, and may even replace it.

The *subcostal arteries*, right and left, are the last branches of the descending thoracic aorta. They are serially continuous with the aortic intercostal arteries above, and with the lumbar arteries below. Each vessel winds round the side of the body of the twelfth thoracic vertebra, and, passing beneath the external arcuate ligament of the diaphragm, it enters the wall of the abdomen, where it lies along the lower border of the twelfth rib. These vessels will be found described in connection with the abdomen (see p. 726).

The first and second intercostal spaces receive their arteries from the *superior intercostal artery*, which is a branch of the second part of the subclavian on the right side, and of the first part on the left side. Having descended in front of the neck of the first rib to the posterior extremity of the first intercostal space, the vessel furnishes the first intercostal artery to that space, and it also gives off the second intercostal artery, which descends in front of the neck of the second rib to the second intercostal space. As stated, the second intercostal artery receives a branch from the third intercostal artery, which ascends over the neck of the third rib, the third intercostal being the first aortic intercostal.

Development of the Descending Aorta.—The upper portion of the descending aorta is developed from that part of the *left* primitive dorsal aorta which lies between the fourth left arterial arch and the place of junction of the two primitive dorsal aortæ. The greater portion of it, however, results from the union of the two primitive dorsal aortæ.

Intercostal Veins.—The intercostal veins are eleven in number on either side, and each lies in the subcostal groove above the corresponding aortic intercostal artery. In the region of the angle of the rib each vein receives the *collateral intercostal vein*, which accompanies the artery of that name. At the posterior extremity of an intercostal space each vein receives a large *dorsal branch*, which returns blood from the muscles and integument of the back, the dorsal spinal venous plexus, and the spinal canal. With the exception of the upper three or four veins, all the other intercostal veins pass inwards, behind the corresponding sympa-

thetic cord, on to the bodies of the thoracic vertebræ, from which they receive small twigs. Their mode of termination differs on the two sides. On the *right side* the veins, having passed behind the œsophagus, terminate in the right azygos vein. On the *left side* the lower four veins, namely, the eighth, ninth, tenth, and eleventh, open into the lower left azygos vein; and the succeeding three (or four), namely, the fifth, sixth, and seventh (and, it may be, the fourth also), open into the upper left azygos vein.

The **first intercostal vein** of each side accompanies the corresponding superior intercostal artery, and terminates in the innominate vein, or, it may be, in the vertebral vein, of its own side.

The **second** and **third intercostal veins** (and, it may be, the fourth) of each side unite to form the superior intercostal vein. The **right superior intercostal vein,** after a downward course, joins the upper part of the right azygos vein. The **left superior intercostal vein** ascends over the back part of the arch of the aorta, and opens into the left innominate vein. It sometimes receives the left bronchial vein as a tributary.

Summary of the Intercostal Veins—Right Intercostal Veins.—The first opens into the right innominate vein, or sometimes into the right vertebral vein. The second and third (and, it may be, the fourth also) unite to form the right superior intercostal vein, which opens into the right azygos vein. The lower eight (sometimes the lower seven) are direct tributaries of the right azygos vein.

Left Intercostal Veins.—The first opens into the left innominate vein, or sometimes into the left vertebral vein. The second and third (and it may be the fourth also) unite to form the left superior intercostal vein, which opens into the left innominate vein. The fifth, sixth, and seventh (and, it may be, the fourth also) terminate in the upper left azygos vein. The eighth, ninth, tenth, and eleventh are tributaries of the lower left azgyos vein.

The left superior intercostal vein is developed from two sources. The *upper part* is formed by the portion of the left primitive jugular vein below, and adjacent to, the commencement of the transverse jugular vein. The *lower part* is formed by the upper portion of the left cardinal vein.

Azygos Veins.—These are three in number, one right and two left.

The **vena azygos major** or **right azygos vein** commences in the abdomen as the *right ascending lumbar vein*, and enters the thorax through the aortic opening of the diaphragm, lying on the right side of the aorta, the thoracic duct intervening. It then ascends, under cover of the œsophagus, upon the bodies of the thoracic vertebræ, crossing in its course the right aortic intercostal arteries. Having reached the level of the fifth thoracic vertebra it leaves the vertebral column, and, arching forwards over the right bronchus, it opens into the superior vena cava, just before that vessel pierces the pericardium. In the thorax the right azygos vein continues to lie on the right side of the aorta, the thoracic duct intervening.

Tributaries.—These are as follows:

1. The right subcostal vein.
2. The lower seven (sometimes the lower eight) right intercostal veins.

3. The right superior intercostal vein.
4. The right bronchial vein.
5. Some œsophageal veins.
6. Some pericardial veins.
7. The lower and upper transverse azygos veins.

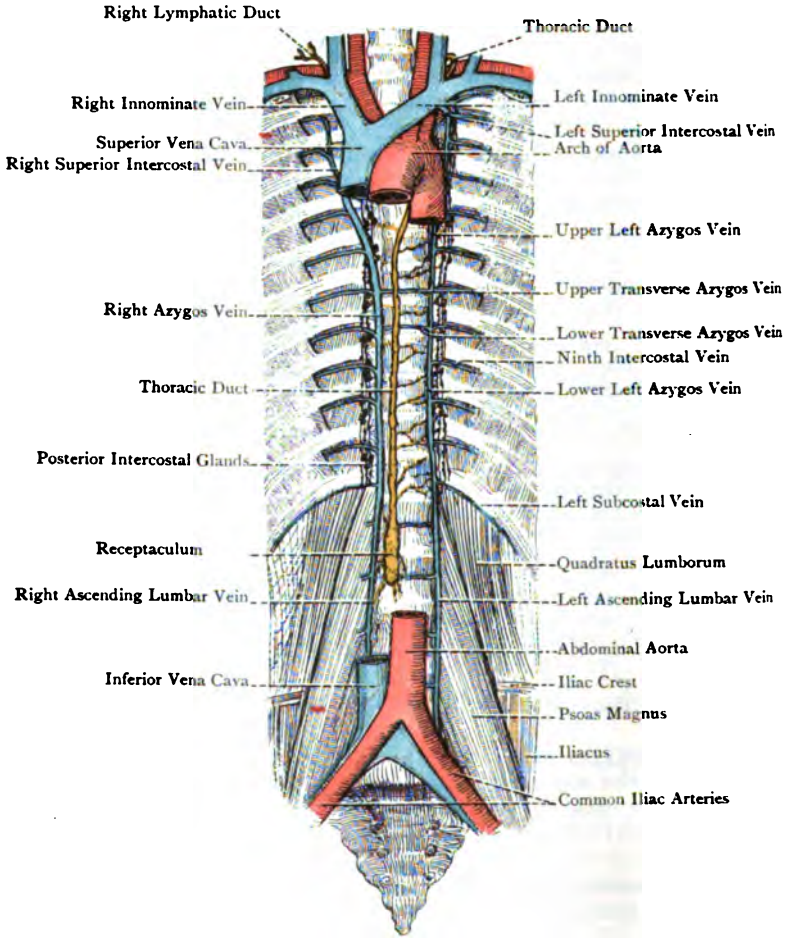


FIG. 406.—THE THORACIC DUCT, AZYGOS VEINS, AND POSTERIOR INTERCOSTAL GLANDS.

The **vena azygos minor** or **lower left azygos vein** commences in the abdomen as the *left ascending lumbar vein*, and enters the thorax by piercing the left crus of the diaphragm. It ascends upon the vertebral column to the level of the eighth thoracic ver-

tebra, lying in front of the lower aortic intercostal arteries, and it takes up the lower four left intercostal veins. It then crosses the vertebral column from left to right, under the name of the *lower transverse azygos vein*, passing behind the descending aorta and thoracic duct, and thereafter it opens into the right azygos vein.

Tributaries.—These are as follows :

1. The left subcostal vein.
2. The lower four left intercostal veins.
3. Some œsophageal veins.

The **upper left, or accessory, azygos vein** is formed by the union of the fifth, sixth, and seventh left intercostal veins (sometimes also the fourth). At the level of the seventh thoracic vertebra it crosses the vertebral column from left to right, under the name of the *upper transverse azygos vein*, passing behind the descending aorta and thoracic duct, and thereafter it opens into the right azygos vein. It communicates above with the left superior intercostal vein, and below with the lower left azygos vein.

Tributaries.—These are as follows :

1. The fifth, sixth, and seventh left intercostal veins (sometimes also the fourth).
2. The left bronchial vein, as a rule.
3. Some œsophageal veins.

The lower and upper left azygos veins, which are subject to much variation, sometimes unite to form one transverse azygos vein.

Summary of the Azygos Veins—Right Azygos Vein.—This vessel receives (1) the right subcostal vein; (2) the lower seven (sometimes the lower eight) right intercostal veins; (3) the right superior intercostal vein; (4) the right bronchial vein; (5) some œsophageal veins; (6) some pericardial veins; and (7) the lower and upper transverse azygos veins.

Lower Left Azygos Vein.—This vessel receives (1) the left subcostal vein; (2) the lower four left intercostal veins; and (3) some œsophageal veins.

Upper Left Azygos Vein.—This vessel receives (1) the fifth, sixth, and seventh (sometimes also the fourth) left intercostal veins; (2) the left bronchial vein, as a rule; and (3) some œsophageal veins.

The right azygos vein and the lower left azygos vein, through their connections with the ascending lumbar veins, establish communications with the inferior vena cava and with the common iliac veins or some of their tributaries. They therefore form important channels by which a considerable quantity of blood is returned from the lower limbs and abdominal wall in cases of obstruction of the inferior vena cava.

Development. — The **right azygos vein** is developed from the thoracic portion of the right cardinal vein. The **lower** and **upper left azygos veins** are developed from the thoracic portion of the left cardinal vein.

Subcostal Veins.—These are two in number, right and left, and they are serially continuous with the intercostal veins. Each vessel enters the thorax from the abdomen by passing behind the

external arcuate ligament of the diaphragm. As stated, the right vein opens into the right azygos vein, and the left into the lower left azygos vein.

Anterior Primary Divisions of the Thoracic Spinal Nerves.—These are twelve in number on each side. The first eleven enter intercostal spaces, and are called the **intercostal nerves.** The last, which belongs to the abdomen, lies along the lower border of the twelfth rib, and is called the **subcostal nerve** ('last dorsal nerve'). At the posterior extremities of the intercostal spaces the intercostal nerves are near the gangliated cord of the sympathetic, and each nerve is connected with the adjacent sympathetic ganglion by two *rami communicantes*, which are necessarily very short. One of these rami, being composed of spinal fibres, is *white*, and the other, which consists of sympathetic fibres, is *grey*. Each intercostal nerve lies below the corresponding artery, and, like it, lies between the parietal pleura and the posterior intercostal aponeurosis, as far as the angle of the rib. Its subsequent course corresponds to that of the artery. The first intercostal nerve is of small size, because the greater part of the anterior primary division of the first thoracic nerve takes part in the formation of the brachial plexus. The second intercostal nerve sometimes gives off a small branch which ascends to join the portion of the anterior primary division of the first thoracic nerve which takes part in the brachial plexus. The further course and distribution of the intercostal nerves belong to the thoracic and abdominal walls, in connection with which they will be found described.

Thoracic Duct.—The thoracic duct commences in the abdomen in a dilatation, called the **receptaculum chyli,** which is situated in front of the bodies of the first and second lumbar vertebræ, and it terminates by opening into the angle of junction of the internal jugular and subclavian veins of the left side. It is about 18 inches in length, and enters the thorax from the abdomen by passing through the aortic opening of the diaphragm, where it lies between the aorta on the left and the right azygos vein on the right. In this position it ascends in the thorax, resting upon the vertebral column, the right aortic intercostal arteries, and the lower and upper transverse azygos veins, being under cover of the œsophagus. Up to the level of the fourth or fifth thoracic vertebra it occupies the middle line. At this level it passes behind the arch of the aorta, inclining to the left of the middle line. Thereafter it ascends in close contact with the left side of the œsophagus, and behind the thoracic portion of the left subclavian artery. In this position it enters the root of the neck on the left side, where it ascends upon the left side of the œsophagus, between the left common carotid and left subclavian arteries. At about the level of the seventh cervical vertebra it describes a curve, and passes outwards, forwards, and downwards, in contact with the dome of the left pleura. Thereafter it inclines inwards, and terminates by opening into the angle of junction between the internal jugular and subclavian veins

of the left side. In the lower part of the thorax the thoracic duct is of smaller calibre than in the upper part. Its course is somewhat undulating, and when distended it presents a beaded appearance, especially in the upper part, due to the number of valves with which it is provided. Sometimes the duct divides into two branches in the lower part of the thorax, which reunite at a higher level. The duct is freely provided with valves, especially in its upper part, and at its termination there is an important valve, consisting of two segments, which are so directed as to prevent effectually the reflux of chyle, or the flow of blood, into the duct.

The thoracic duct receives lymphatic vessels from the following sources: (1) the lower limbs; (2) the abdomen and its viscera, except some of the lymphatics from part of the upper surface of the liver; (3) the left half of the thoracic wall; (4) the left lung and the left half of the heart; (5) the left upper limb; and (6) the left side of the head and neck. Most of the lymphatics of the right half of the thorax and those of the right lung and right half of the heart pass to the right lymphatic duct, for the description of which see the section dealing with the neck.

Thoracic Lymphatic Glands.—These are arranged in several groups, as follows: anterior intercostal or sternal, posterior intercostal, superior mediastinal, anterior mediastinal, posterior mediastinal, bronchial, and caval.

The **anterior intercostal** or **sternal glands** will be found described on p. 877. They receive their afferent vessels from (1) the anterior parts of the upper six intercostal spaces; (2) the inner portion of the mammary gland; (3) the lymphatics accompanying the superior epigastric artery from the upper part of the anterior abdominal wall; and (4) the lymphatics accompanying the musculo-phrenic artery from the anterior parts of the seventh, eighth, and ninth intercostal spaces, and from a portion of the diaphragm. The efferent vessels of the right glands terminate in the right lymphatic duct, and those of the left glands in the thoracic duct.

The **posterior intercostal glands** are situated on either side of the vertebral column, where they lie in the intercostal spaces, there being from one to three in each space. They receive their afferent vessels from (1) the posterior parts of the intercostal spaces; (2) the parietal pleura; (3) the spinal canal; and (4) the deep muscles of the back. The efferent vessels of the left intercostal glands open into the thoracic duct. On the right side the efferent vessels from the lower glands pass to the thoracic duct, but those from the upper glands open into the right lymphatic duct.

The **superior mediastinal glands** lie in the superior mediastinum in relation to the arch of the aorta and the innominate veins, and they are continuous with the posterior mediastinal and bronchial glands. They receive their afferent vessels from the pericardium, the heart, and the thymus body in early life, and their efferent vessels pass to the thoracic duct and right lymphatic duct.

The **anterior mediastinal glands** lie in the lower part of the anterior

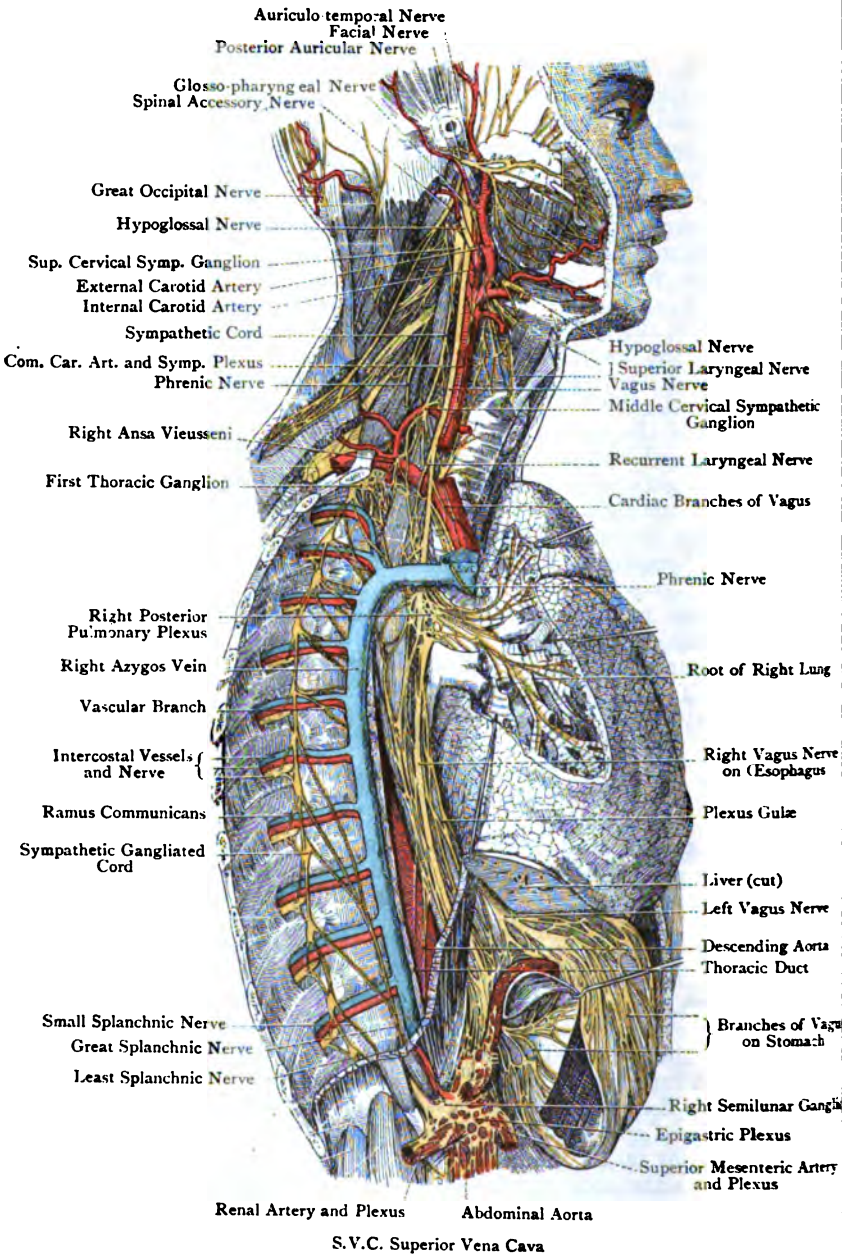


FIG. 407.—NERVES OF THE RIGHT SIDE OF THE FACE, NECK, AND THORAX (HIRSCHFELD AND LEVEILLÉ).

mediastinum, in front of the pericardium. They receive their afferent vessels from (1) the mesial portions of the right and left lobes of the liver in the vicinity of the falciform ligament; (2) the adjacent portion of the diaphragm; (3) the anterior part of the pericardium; and (4) the lower anterior intercostal or sternal glands. Their efferent vessels pass to the thoracic duct and right lymphatic duct.

The **posterior mediastinal glands** are situated in the posterior mediastinum, along the course of the descending aorta and œsophagus. They receive their afferent vessels from the œsophagus, the posterior part of the pericardium, and the vertebral portion of the diaphragm. Their efferent vessels pass, for the most part, to the thoracic duct.

The **bronchial glands** are very numerous, and are situated partly between the two bronchi, where these spring from the trachea, and partly at the root of each lung. They are very dark in colour, and receive their afferent vessels from the lungs and the visceral pleuræ. Their efferent vessels pass to the thoracic duct and right lymphatic duct.

The **caval glands** are situated in contact with the limited thoracic portion of the inferior vena cava. They receive their afferent vessels from the uncovered area of the posterior surface of the liver, and also those deep lymphatics of that organ which accompany the hepatic veins to the caval fossa. Their efferent vessels pass to the thoracic duct.

Gangliated Cord of the Sympathetic.—The sympathetic system in the thorax consists of (1) two gangliated cords, right and left, and (2) a prevertebral plexus, namely, the cardiac plexus. The latter plexus has been already described. The gangliated cord lies on each side of the vertebral column behind the parietal pleura, and superficial to the intercostal vessels. It presents, as a rule, twelve ganglia, but the first is frequently united with the inferior cervical ganglion, in which cases the number is reduced to eleven. The upper ten ganglia are placed upon the heads of the corresponding ribs, but the lower two lie upon the sides of the bodies of the eleventh and twelfth thoracic vertebræ. The first thoracic ganglion is the largest of the thoracic series, and is known as the *ganglion stellatum*. The sympathetic cord leaves the thorax by passing behind the inner part of the internal arcuate ligament of the diaphragm, and so enters the abdomen.

Branches—1. **Of Communication.**—These are called the *rami communicantes*. Two of these, one *white* and the other *grey*, pass between each ganglion and the adjacent intercostal nerve. The white fibres are of spinal, and the grey of sympathetic, origin. From the proximity of the ganglia to the intercostal nerves the rami communicantes are characterized by their shortness.

2. **Of Distribution.**—From the upper five ganglia small *vascular branches* are given off, which are distributed to the coats of the thoracic aorta. From the second, third, and fourth ganglia *pul-*

monary branches are given off to the posterior pulmonary plexus. From the fifth ganglion downwards the three splanchnic (' visceral ') nerves—great, small, and least—are given off.

The **great splanchnic nerve** arises by five separate roots from the fifth, sixth, seventh, eighth, and ninth ganglia, the fibres of the upper roots being traceable in the sympathetic cord as high as the second ganglion. The roots arch obliquely forwards and downwards upon the sides of the bodies of the adjacent vertebræ, and by their union they form a large nerve, which pierces the crus of the diaphragm and terminates in the semilunar ganglion of the epigastric or solar plexus. The great splanchnic nerve contains a large number of spinal fibres, which impart to it a white colour and firm consistence. The right nerve presents a small ganglion just before it leaves the thorax, called the *splanchnic ganglion*, and there may be one on the left nerve. The great splanchnic nerve gives vascular branches to the lower part of the thoracic aorta.

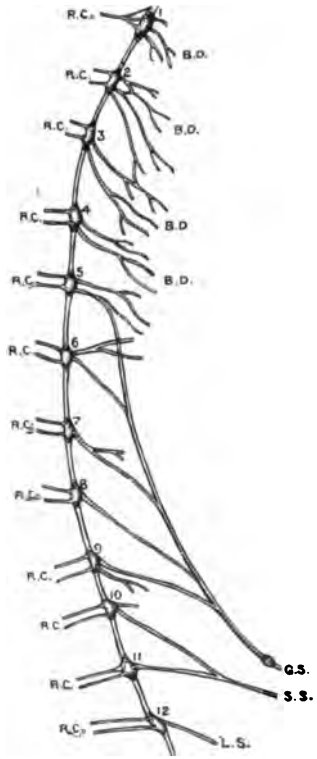


FIG. 408.—SCHEME OF THE GANGLIATED CORD OF THE SYMPATHETIC IN THE THORAX (AFTER FLOWER).

1 to 12. Thoracic Ganglia
R.C. Rami Communicantes
B.D. Branches of Distribution from Upper Ganglia
G.S. Great Splanchnic Nerve and Ganglion
S.S. Small Splanchnic Nerve
L.S. Least Splanchnic Nerve

The **small splanchnic nerve** arises by two roots from the tenth and eleventh ganglia. It pierces the crus of the diaphragm, and terminates in the aortico-renal ganglion of the epigastric or solar plexus.

The **least splanchnic nerve,** which is sometimes absent, arises by one root from the twelfth ganglion. It either passes behind the internal arcuate ligament of the diaphragm or through the crus, and it terminates in the renal plexus. When the least splanchnic nerve is absent, its place may be taken by a branch from the small splanchnic nerve.

Subcostal Muscles. — These are small indefinite muscular sheets, which lie on the inner surfaces of the ribs in the region of the angles. They coincide in direction with the internal intercostal muscles, and are best developed inferiorly. They are attached to the inner surfaces of the ribs

near the angles, and each muscle crosses over one, or it may be two, intercostal spaces.

They are supplied by the intercostal nerves.

The diaphragm will be found described in connection with the abdomen.

The Articulations of the Vertebral Column.

1. **Articulations of the Bodies of the Vertebræ.**—These joints belong to the class **amphiarthrosis.** The ligaments are as follows: the anterior common ligament, the posterior common ligament, and the intervertebral discs.

The **anterior common ligament** is a dense band of white glistening fibres, which extends over the anterior surfaces of the bodies of

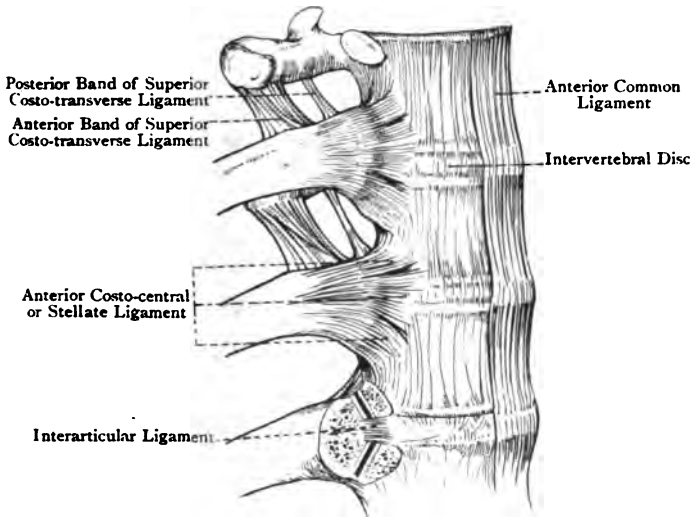

Posterior Band of Superior Costo-transverse Ligament
Anterior Band of Superior Costo-transverse Ligament
Anterior Costo-central or Stellate Ligament
Interarticular Ligament
Anterior Common Ligament
Intervertebral Disc

FIG. 409.—LIGAMENTS OF THE BODIES OF THE VERTEBRÆ AND RIGHT COSTO-CENTRAL JOINTS.

the vertebræ and intervertebral discs. It extends from the axis to the first segment of the sacrum, and its fibres are disposed longitudinally. The most superficial fibres extend from a given vertebra to the fifth below it; the intermediate fibres pass from a given vertebra to the third below it; and the deepest fibres pass from a given vertebra to the one immediately below it. The fibres are firmly attached to the intervertebral discs and margins of the vertebral bodies, but very loosely to the centres of the bodies, on account of the presence of bloodvessels. The anterior common ligament is broadest in the lumbar region, and thickest in the

thoracic region. It is thicker opposite the centres of the bodies than elsewhere, and in these situations it fills up the concavities, and so renders the front of the column less undulating than it otherwise would be. Over the lateral surfaces of the bodies a few scattered fibres are present, which pass from one vertebra to that below. In the sacral region the anterior common ligament is lost in the periosteum of the bone, but it reappears lower down as the anterior sacro-coccygeal ligament. The anterior common ligament is serially continuous superiorly with the anterior atlanto-axial ligament.

The **posterior common ligament** is situated within the spinal canal, and extends over the posterior surfaces of the bodies of the

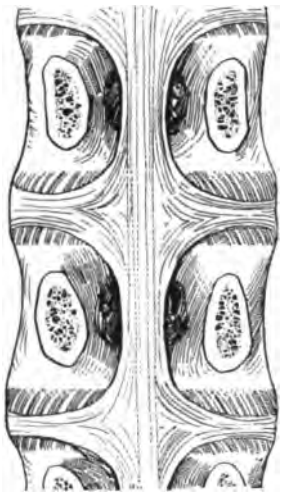


FIG. 410.—POSTERIOR COMMON LIGAMENT OF THE BODIES OF THE VERTEBRÆ.

FIG. 411.—INTERVERTEBRAL DISCS (ANTERIOR VIEW).

vertebræ and intervertebral discs. It is broader above than below, and consists of glistening fibres, which extend from the axis to the first coccygeal vertebra, its sacral part, however, being very narrow and delicate. Its fibres are firmly attached to the intervertebral discs and margins of the vertebral bodies, but they are separated from the centres of the bodies by the transverse venous communications between the anterior intraspinal veins. In the cervical region the ligament is of almost uniform breadth, being expanded over the vertebral bodies, as well as over the intervertebral discs. In the thoracic and lumbar regions, however, it is narrow opposite the vertebral bodies, and broad opposite the intervertebral discs. Its margins, therefore, present dentations, which give it a denticulated appearance. The arrangement of its fibres is similar to the

arrangement of those of the anterior common ligament. The posterior common ligament is serially continuous superiorly with the posterior occipito-axial ligament.

The **intervertebral discs** are situated between the adjacent surfaces of the bodies of the vertebræ, and they constitute the chief bond of union between them. Their outline corresponds to that of the bodies between which they are placed, and they are elastic and compressible, Except in early life, the first or highest disc is situated between the bodies of the axis and the third cervical vertebra, and in the adult the last or lowest disc is situated between the bodies of the fifth lumbar and first sacral vertebræ.

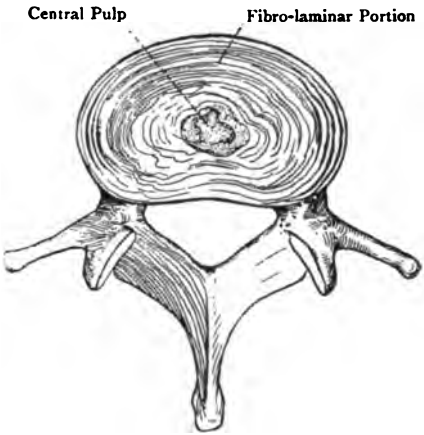


FIG. 412.—INTERVERTEBRAL DISC (TRANSVERSE SECTION).

Each disc is composed of a circumferential fibrous part, disposed in the form of superimposed laminæ, and a central portion, which is soft and pulpy. The *external laminar part* forms more than half of the disc, and is composed of fibrous tissue and fibro-cartilage. As seen in transverse section the laminæ are arranged concentrically around the central pulp, which they closely embrace and compress. The fibres of which they are composed are arranged in parallel bundles, which extend obliquely between the adjacent surfaces of the vertebral bodies, being attached to the layer of hyaline cartilage which covers them. The fibres of successive laminæ pass obliquely in opposite directions, and are disposed thus **X**. The outer laminæ consist of fibrous tissue, but the majority are composed of white fibro-cartilage. As seen in vertical section the outermost laminæ are bent outwards, and those around the central pulp are bent inwards towards it, this arrangement contributing to

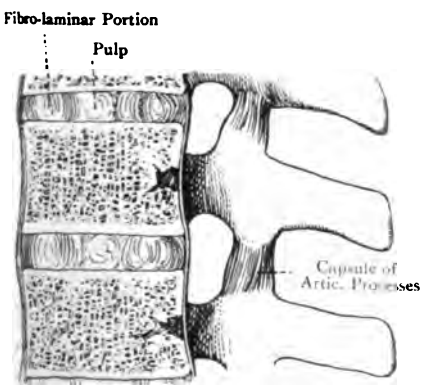


FIG. 413.—VERTICAL SAGITTAL SECTION OF TWO INTERVERTEBRAL DISCS.

the elasticity of the vertebral column. The *central portion* of the disc consists of a soft, elastic, pulpy substance, having a lobate arrangement. Being surrounded and compressed on all sides by the external laminar part, when a section of a disc is made the pulp, being relieved from pressure, projects beyond the level of the cut surface. It is composed of a cellular reticulum, supported by a delicate fibrous stroma.

The pulp is a persistent portion of the notochord.

The intervertebral discs form about one-fourth of the length of the vertebral column, and are thickest in the lumbar region. In the cervical and lumbar regions they are deeper in front than behind, and they give rise to the curve forwards in the cervical region, whilst they increase the forward curve in the lumbar region. In the thoracic region they are of uniform depth. Throughout the

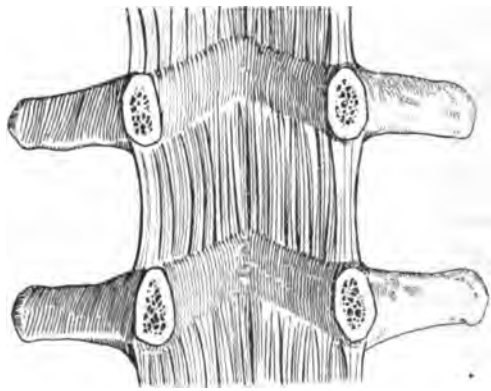


FIG. 414.—LIGAMENTA SUBFLAVA IN THE LUMBAR REGION (ANTERIOR VIEW)

(The Pedicles have been sawn through, and the Vertebral Bodies removed).

column they are intimately connected with the anterior and posterior common ligaments, and, in the thoracic region, with the anterior costo-central or stellate ligaments and the interarticular ligaments of the heads of most of the ribs. In the cervical region the discs are not present at either lateral aspect of the opposed surfaces of the bodies. In these regions there is a synovial space on either side, between the projecting lateral lip of the upper surface of the lower body and the bevelled lateral margin of the lower surface of the upper body. The opposed surfaces are covered by cartilage, and there is an indistinct capsular ligament.

2. **Ligaments of the Laminæ.**—These are called the **ligamenta subflava.** They are strong, thick plates of yellow elastic tissue, which connect the laminæ together, and they extend from the axis to the first sacral segment. They are best seen from the interior

of the spinal canal, and as they extend between the neural arches they close in the canal in these situations. Each ligamentum subflavum extends from the root of the articular process to the place where the lamina joins its fellow to form the spinous process. At this point it comes into relation with the ligament of the opposite side, a small interval being left between the two for the passage of veins. Superiorly the ligament is attached to the anterior surface of the upper lamina a little above its lower border, and inferiorly it is attached to the upper border, and adjacent part of the posterior surface, of the lower lamina. The ligamenta subflava are wider in the cervical and lumbar regions than in the thoracic region, and over the greater part of the latter region, as viewed from the exterior, they are concealed from view by the imbricated laminæ. Their importance consists in their great elasticity, which enables them to maintain the vertebral column erect, and to restore it to the erect position after it has been bent forwards.

3. **Ligaments of the Articular Processes.**—The joints between the articular processes belong to the class **diarthrosis,** and to the subdivision **arthrodia.** The articular surfaces are covered by cartilage, and the joint is surrounded by a **capsular ligament,** lined with a synovial membrane. These ligaments are disposed more loosely in the cervical region than elsewhere.

4. **Ligaments of the Spinous Processes.**—These are supraspinous and interspinous.

The **supraspinous ligament** consists of longitudinal fibres which connect the extremities of the spinous processes. It extends from the spine of the seventh cervical vertebra to the spine of the fourth sacral segment, and its fibres are arranged in a manner similar to those of the anterior common ligament. In the cervical region the supraspinous ligament is replaced by the ligamentum nuchæ. The **interspinous ligaments,** which are thin and membranous, are situated between adjacent spinous processes, to the margins of which they are attached from root to tip. They are strongest in the lumbar region, and in the neck they are replaced by deep processes of the ligamentum nuchæ.

5. **Ligaments of the Transverse Processes.**—These consist of scattered fibres, which pass between the extremities of the transverse processes in the thoracic and lumbar regions. In the neck they are replaced by the intertransversales muscles.

Movements.—The movements allowed in the vertebral column are flexion, extension, lateral movement, rotation, and circumduction.

Flexion and **extension** are freely allowed in the cervical and lumbar regions. In the thoracic region these movements are very limited on account of (1) the small amount of intervertebral substance, and (2) the imbrication of the laminæ. **Lateral flexion** is allowed in the cervical, thoracic, and lumbar regions, but in the neck it is associated with rotation. During these combined movements of lateral flexion and rotation in the neck one inferior articular process glides upwards and forwards on that which is opposed to it, whilst the other inferior articular process glides downwards and backwards on the one opposed to it. Pure **rotation** is allowed in the thoracic region round an axis corresponding with the centre of a circle of which the surfaces

of the articular processes form segments. This centre is necessarily anterior to the articular processes, and corresponds pretty nearly with the centres of the bodies of the vertebræ. In the lumbar region rotation is impossible, for the following two reasons: (1) the centre of the circle of which the articular processes form segments is posterior to these processes; and (2) the articular processes are so disposed as to be locked. In the lumbar region **circumduction** is allowed, which consists in a combination of flexion, extension, and lateral movements.

Summary of Movements—Cervical Region.—(1) Flexion and extension; and (2) a combination of lateral flexion and rotation. **Thoracic Region.**—(1) Flexion and extension, but only to a limited extent; (2) lateral flexion; and (3) pure rotation. **Lumbar Region.**—(1) Flexion and extension; (2) lateral flexion; and (3) circumduction.

The articulations of the atlas, axis, and occipital bone will be found described in the section dealing with the head and neck.

THE ARTICULATIONS OF THE RIBS, COSTAL CARTILAGES, AND STERNUM.

1. **Ribs—Costo-vertebral Articulations.**—These are divided into costo-central and costo-transverse.

Costo-central Articulations.—These unite the heads of the ribs to the centra or bodies of the thoracic vertebræ, and they are sometimes spoken of as the *capitular joints*. They belong to the class **diarthrosis,** and to the subdivision **condylarthrosis.** The articular surfaces are the demi-facets on the heads of the ribs and the demi-facets on the sides of the bodies of the thoracic vertebræ, that is to say, the lower demi-facet of the vertebra above and the upper demi-facet of the vertebra below, the intervertebral disc intervening between the two. In the case of the 1st, (sometimes the 10th), the 11th, and the 12th vertebræ there is only one facet, and the corresponding intervertebral discs do not enter into the joints, unless in the case of the 1st joint, into which the disc between the 7th cervical and 1st thoracic vertebræ may enter.

Ligaments.—These are as follows: anterior costo-central, capsular, and interarticular.

The **anterior costo-central ligament** consists of strong white fibres which are attached to the anterior margin of the head of the rib. From this point the fibres radiate inwards in three bands, one of which passes upwards to be attached to the body of the vertebra above, a second horizontally inwards to be attached to the intervertebral disc, and a third downwards to be attached to the body of the vertebra below. From the radiating disposition of these bands the ligament is known by the name of **stellate** or **radiate.** In the case of the 1st, 10th, 11th, and 12th joints, into each of which only one vertebra enters, the ligament is composed of two bands, instead of three. In the 1st joint the lower band passes to the

body of the 1st thoracic vertebra, and the upper band to the body of the 7th cervical. In each of the 10th, 11th, and 12th joints the lower band passes to the body with which the head of the rib articulates, and the upper band to the body of the vertebra above.

The **capsular ligament** is incomplete, and consists of thin loose fibres, which cover the posterior, superior, and inferior aspects of the joint.

The **interarticular ligament** consists of short stout fibres, which extend from the ridge on the head of the rib, separating the two facets, to the intervertebral disc. It divides the joint into two complete synovial cavities, and it is wanting in the 1st, 10th, 11th, and 12th joints.

There are two distinct **synovial membranes** in those joints which are provided with an interarticular ligament, namely, from the

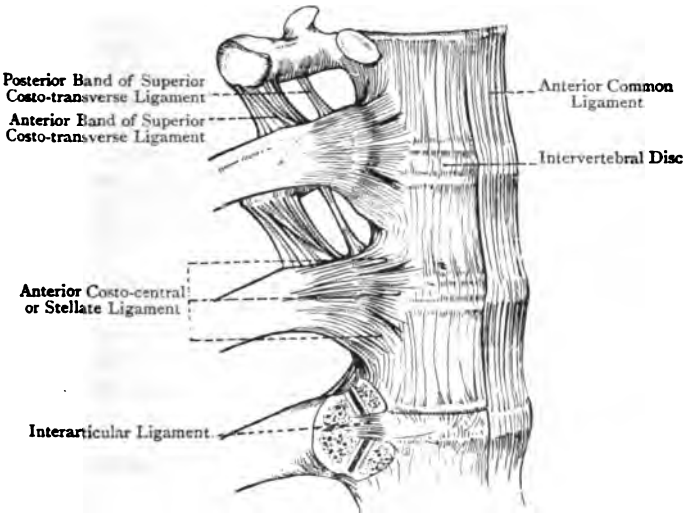

Posterior Band of Superior Costo-transverse Ligament
Anterior Band of Superior Costo-transverse Ligament
Anterior Common Ligament
Intervertebral Disc
Anterior Costo-central or Stellate Ligament
Interarticular Ligament

FIG. 415.—LIGAMENTS OF THE BODIES OF THE VERTEBRÆ AND RIGHT COSTO-CENTRAL JOINTS.

2nd to the 9th inclusive, one being above the ligament and the other below it. In those joints in which the interarticular ligament is absent, namely, the 1st, 10th, 11th, and 12th, there is only one synovial membrane.

Arterial Supply.—Branches from the intercostal arteries.

Nerve-supply.—Branches from the intercostal nerves.

Costo-transverse Articulations.—These belong to the class **diarthrosis,** and to the subdivision **arthrodia.** The articular surfaces are the facet on the tubercle of the rib and the facet on the anterior aspect of the extremity of the transverse process of the thoracic vertebra.

Ligaments.—These are as follows: posterior costo-transverse, middle costo-transverse, superior costo-transverse, and capsular.

The **posterior costo-transverse ligament** is a strong flat band, situated on the posterior aspect of the joint, and extending from the extremity of the transverse process to the non-articular part of the tubercle of the rib. The direction of its fibres is upwards and outwards.

The **middle costo-transverse** or **interosseous ligament** consists of short strong fibres which pass between the posterior surface of the neck of the rib and the anterior surface of the adjacent transverse process, namely, that with which the tubercle of the rib articulates. Its fibres, which are disposed horizontally, extend from the costo-central to the costo-transverse joint. This ligament is rudimentary in the 11th and 12th ribs.

The **superior costo-transverse ligaments** are two in number, anterior and posterior. The *anterior* ligament is a broad flat band, external in position, the fibres of which pass from the crest on the upper border of the neck of the rib to the lower border of the transverse process immediately above, in the vicinity of its tip. Its fibres are directed upwards and outwards, and its outer border is continuous with the posterior intercostal aponeurosis. The *posterior* ligament is a narrow band, internal to the preceding, and extending from the back of the neck of the rib, below the crest, to the lower aspect of the transverse process immediately above, close to its base.

The superior costo-transverse ligaments are wanting in the case of the 1st rib.

The **capsular ligament** is formed in part by the posterior costo-transverse ligament, and elsewhere by a thin loose membrane, the fibres of which are attached external to the articular processes. It is absent in the case of the 11th and 12th ribs.

The **synovial membrane** is single and small.

Arterial and Nerve Supply.—Offsets from the posterior branches of the intercostal arteries and nerves.

The costo-transverse articulations are wanting in the case of the 11th and 12th ribs, and sometimes in the case of the 10th.

Costo-chondral Articulations.—These belong to the class **synarthrosis.** The outer extremity of the costal cartilage is implanted in the oval pit on the anterior extremity of the rib, and the union is effected by the continuity which takes place between the periosteum of the rib and the perichondrium of the cartilage.

2. **Costal Cartilages—Chondro-sternal Articulations.**—These belong to the class **diarthrosis,** and to the subdivision **ginglymus,** except in the case of the 1st joint, which belongs to the class **synarthrosis.** The cartilages which take part in these joints are the first seven on either side, these being received into the costal pits or facets on the side of the sternum.

The ligaments are anterior, posterior, superior, and inferior, and, in the case of the 2nd joint at least, interarticular.

The **anterior chondro-sternal ligament** is a triangular band, the upper fibres of which ascend upon the sternum, and the lower descend, whilst the intervening fibres pass horizontally forwards. They decussate with those of the opposite side, and blend with the tendinous fibres of origin of the pectoralis major muscle.

The **posterior chondro-sternal ligament** is disposed in a manner similar to the anterior ligament.

The **superior** and **inferior chondro-sternal ligaments** pass from the upper and lower borders of the costal cartilage to the side of the sternum.

The **interarticular ligament** is present in the 2nd joint, and may be present in some of those succeeding to it. Its fibres extend horizontally between the centre of the sternal end of the 2nd costal cartilage and the plate of fibro-cartilage between the manu-

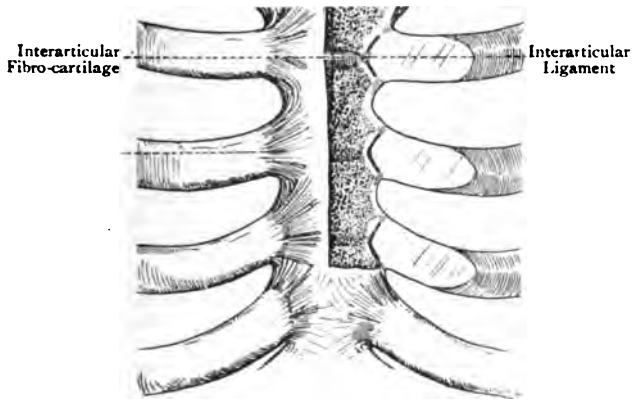


FIG. 416.—THE CHONDRO-STERNAL JOINTS (ANTERIOR VIEW).
The Second, Third, and Fourth Joints of the Left Side are seen in Section.

brium and body of the sternum. It divides this joint into two complete synovial cavities.

The 1st joint has no synovial membrane, the first costal cartilage being directly united to the manubrium sterni. The 2nd joint, as stated, has two synovial membranes, one above and the other below the interarticular ligament. The succeeding joints have each usually one synovial membrane, but sometimes one or more of them may have two.

Arterial Supply.—The anterior or perforating branches of the internal mammary artery.

Nerve-supply.—The intercostal nerves as they are becoming the anterior cutaneous nerves.

Interchondral Articulations.—These belong to the class **diarthrosis,** and to the subdivision **arthrodia.** The cartilages involved are usually the 6th, 7th, and 8th, but sometimes also the 9th,

and it may be the 5th, and even the 10th. The lower border of each cartilage projects downwards, and comes into contact with the upper border of the cartilage below, the contiguous surfaces being faceted. Each joint is surrounded by fibres disposed in the form of a capsule, and it is provided with a synovial membrane.

Arterial Supply.—The musculo-phrenic branch of the internal mammary artery.

Nerve-supply.—The adjacent intercostal nerves.

3. **Sternal Articulations.**—The joint between the manubrium and body of the sternum belongs to the class **amphiarthrosis.** The opposed surfaces are covered by hyaline cartilage, and a plate or disc of fibro-cartilage is interposed between them, which is connected at either side with the interarticular ligament of the second chondro-sternal joint. This disc may contain a small cavity. In front of and behind the joint there are ligamentous fibres which are disposed longitudinally.

The entire sternum is strengthened by its dense periosteum, by the radiating fibres of the chondro-sternal ligaments, and by the tendinous fibres of origin of the pectoralis major muscles.

Movements of the Ribs.—The movement allowed at the **costo-central** and **costo-transverse joints** is of a *gliding* nature, and takes place in an upward and downward direction. During this movement the rib *rotates* round the **costo-vertebral axis,** which corresponds to a line passing obliquely through the costo-central joint, the neck of the rib, and the costo-transverse joint. Owing to the curve and downward inclination of the rib, the result of this rotation is that the anterior and lateral parts of the rib are elevated. Simultaneously, on account of the obliquity of the axis of rotation, the anterior part of the rib is carried forwards, and along with it the sternum, thus increasing the *antero-posterior diameter* of the thorax. The lateral part of the rib, and to a certain extent the anterior part also, are carried outwards, thus giving rise to *eversion* of the lower border of the rib, and at the same time the angle between the rib and its costal cartilage is opened out. In this manner an increase in the *transverse diameter* of the thorax is produced. During the elevation of the anterior and lateral parts of the rib and the eversion of its lower border the movement takes place round the **costo-sternal axis,** which corresponds to a line drawn from the costo-central joint of one side to the corresponding chondro-sternal joint. It is usual to liken this movement to the movement of the handle of a bucket.

In the case of the first rib elevation and depression are the chief movements allowed, the amount of eversion being trivial, inasmuch as the axis of rotation is almost transverse. In the case of the second, third, fourth, fifth, and sixth ribs elevation and depression, along with eversion, are allowed, the axis of rotation in each case becoming successively more oblique. The seventh, eighth, ninth, and tenth ribs, in which the costo-transverse articular surfaces are almost flat, besides rotating round the costo-vertebral axis, also rotate round the costo-sternal axis. In the case of these ribs elevation is accompanied by a backward movement, and depression by a forward movement. These backward and forward movements take place more freely in the case of the eleventh and twelfth ribs, which have no costo-transverse joints. At the chondro-sternal joints the movement is limited, and consists in elevation and depression, together with forward and backward movement.

At the interchondral joints slight gliding movement is allowed.

Muscles concerned in Respiration.—In **ordinary quiet inspiration** the muscles concerned are as follows: (1) the diaphragm; (2) the external and internal intercostal muscles, assuming Haller's view to be correct; (3) the

levatores costarum ; (4) the serratus posticus superior ; (5) the serratus posticus inferior ; and (6) the quadratus lumborum, as being auxiliary to the diaphragm, the serratus posticus inferior being also auxiliary. **Ordinary quiet expiration** is due to (1) the elastic recoil of the lungs, (2) the elastic recoil of the thoracic wall (costal cartilages and sternum), (3) the triangularis sterni muscle, and (4) the muscles of the antero-lateral wall of the abdomen, which press mildly upon the abdominal viscera, and thereby push the diaphragm upwards towards the thorax.

In **forced inspiration** the following muscles come into play : (1) the scaleni ; (2) the sterno-cleido-mastoid ; (3) the serratus magnus ; (4) the pectoralis major and pectoralis minor ; and (5) the latissimus dorsi. As auxiliary muscles

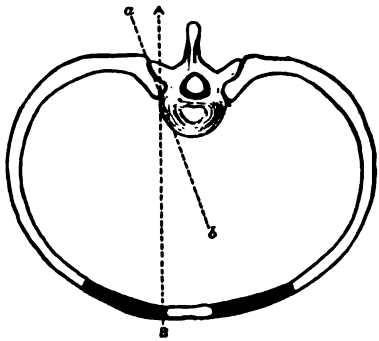


FIG. 417.—DIAGRAM SHOWING THE AXES OF ROTATION OF THE RIBS (FROM HALLIBURTON'S 'HANDBOOK OF PHYSIOLOGY').

A, B, Axis passing from Costo-central to Chondro-sternal Joint ; *a*, *b*, Axis passing through Costo-transverse and Costo-central Joints. (The movement round the axis A, B resembles the raising of the handle of a bucket.)

there are the trapezius, levator anguli scapulæ, and rhomboid muscles, which, by their action upon the scapula, fix the shoulder.

In **forced expiration** the muscles of the antero-lateral wall of the abdomen act with considerable strength, and now depress those ribs with which they are connected, and necessarily also the sternum. By some authorities the serratus posticus inferior is regarded as being concerned.

In inspiration the thoracic cavity is enlarged in its vertical, antero-posterior, and transverse diameters. The increase in the **vertical diameter** is due to the contraction and descent of the diaphragm ; the increase in the **antero-posterior diameter** is caused by the anterior parts of the ribs, and along with them the sternum, being carried forwards ; and the increase in the **transverse diameter** is brought about by the eversion of the lower borders of the ribs, and the opening out of the angles between the ribs and their costal cartilages.

GUIDE TO THE THORAX.

Thoracic Wall.—The upper limb having been separated from the trunk, the dissector should remove the remains of the following muscles : the pectoralis major, pectoralis minor, tendon of origin of the subclavius, serratus magnus, obliquus externus abdominis, latissimus dorsi, and rectus abdominis. In removing the remains of the pectoralis major the anterior cutaneous nerves

should be preserved, as well as the perforating branches of the internal mammary artery. In removing the serrations of the serratus magnus the lateral cutaneous nerves and arteries, which appear between them, should also be preserved.

The insertions of the scalenus anticus and scalenus medius into the first rib, and of the scalenus posticus into the second rib, are to be left intact in the meantime. If the sternum has not been interfered with, for the purpose of injecting the subject from the ascending aorta, the dissector should make himself familiar with the sternal angle at the junction of the manubrium and body of the sternum. In this connection he should note that the angle serves as the guide to the second rib, the cartilage of which articulates partly with the manubrium, and partly with the body of the bone.

The external intercostal muscle is to be dissected in at least two intercostal spaces. The direction of its fibres is to be carefully observed, and it is to be noted that the muscle does not extend farther forwards than the junction of the osseous rib with its costal cartilages; indeed, in some cases not so far as this. The anterior intercostal aponeurosis is also to be shown in the intervals between the costal cartilages. In one or more spaces a small portion of the external intercostal muscle is to be carefully divided transversely, and reflected upwards and downwards in two pieces. This dissection will expose a limited portion of the internal intercostal muscle, and it will enable the dissector to contrast the difference in direction of the two muscles. In another space as much of the external intercostal muscle as possible should be detached from the upper border of the lower rib, and turned upwards with great care, preserving at the same time the lateral cutaneous nerve and artery. The anterior intercostal aponeurosis of the same space should also be carefully removed, care being taken to preserve the anterior cutaneous nerve and perforating artery. This dissection will expose the internal intercostal muscle, the intercostal nerve, and the various intercostal arteries. The direction of the fibres of the internal intercostal muscle is to be observed, and it is to be noted that the muscle extends quite up to the lateral border of the sternum, where it is pierced by the anterior cutaneous nerve.

The intercostal nerve will be found *under cover of* the lower border of the upper rib, where it lies in the subcostal groove, having the aortic intercostal artery above it, the intercostal vein being in turn above the artery. It is well, therefore, to make slight traction upon the nerve before attempting to display it, and for this purpose the lateral cutaneous nerve will suffice, which is one reason for preserving that nerve. The first intercostal nerve, as a rule, gives off no lateral cutaneous branch, and those of the succeeding nerves will be found piercing the external intercostal muscles about midway between the vertebral column and the sternum. Up to this point the intercostal nerve will be met with between the two intercostal muscles, but subsequently it lies in the substance of the internal intercostal muscle, and finally, between the costal cartilages, it is placed beneath the internal intercostal muscle.

The arteries to be dissected in each space are as follows: (1) the aortic intercostal and its collateral intercostal branch, both passing forwards, the former within the lower border of the upper rib, above the nerve, and the latter along the upper border of the lower rib; and (2) the anterior intercostal arteries, two in each space, except the lower two spaces, one lying along the lower border of the upper rib, and the other along the upper border of the lower rib. The internal intercostal muscle should now be carefully removed, after which an instructive view of the parietal pleura will be obtained. This, however, must be left intact.

The dissector is next to turn his attention to the internal mammary vessels and anterior intercostal or sternal glands. These structures are to be displayed in a different manner on the two sides.

On one side the costal cartilages are not to be interfered with in the meantime, and on the other side the second, third, fourth, fifth, and sixth costal cartilages are to be cut through at their inner and outer ends, and then lifted

out. On both sides the anterior intercostal aponeuroses and interchondral fibres of the internal intercostal muscles should be removed. The internal mammary artery and its branches, along with its venæ comites, and the anterior intercostal or sternal glands are then to be dissected. The artery will be found about ½ inch from the side of the sternum, and its superior phrenic branch (comes nervi phrenici) is to be preserved until a later period. The venæ comites are also to be subsequently shown uniting superiorly to form one vessel. In the sixth intercostal space the internal mammary artery is to be shown dividing into its two terminal branches, namely, musculo-phrenic and superior epigastric. The triangularis sterni muscle is then to be dissected from before. On the side on which the costal cartilages have been left intact they are now to be cut through from the second to the sixth inclusive, close to the osseous ribs. Thereafter the ribs corresponding to these costal cartilages on each side are to be divided with the bone-forceps, and this should be done as far back as possible by turning the subject round on either side. The divided ribs are then to be bent backwards, the parietal pleura having been carefully separated from them. The sternum, meanwhile, is to be left undisturbed, with whatever costal cartilages are attached to it. The parietal pleura is then to be carefully studied. By way of showing that it does not descend as low as the line of attachment of the diaphragm, the external and internal intercostal muscles of one or two of the lowest spaces should be removed, when it will be seen that the diaphragm comes into view without any trace of parietal pleura.

The manubrium sterni is next to be partially sawn through near its lower border, the seventh costal cartilage on each side is to be cut through, and the great bulk of the sternum is then to be bent upwards in such a manner that it can be replaced when required. If the bone should break, the two parts should be connected by wire sutures. The relations of the anterior borders of the two pleural sacs to the sternum, to each other, and to the pericardium, are now to be carefully studied. The anterior mediastinum and the remains of the thymus body are to be inspected, and the area of the pericardium which is uncovered by the left pleura, and is directly related to the thoracic wall, is to receive special attention.

At this stage an opening should be made in the cervical portion of the trachea, and a blow-pipe, provided with a stop-cock, should be introduced and tied firmly in position. The lungs are now to be inflated through the blow-pipe, the stop-cock is to be turned, and the following points are to be accurately observed: (1) the extent to which the lungs encroach upon the heart, enclosed within the pericardium; and (2) the extent to which they descend between the diaphragm and the ribs. By reversing the stop-cock the lungs will be seen to collapse and recede from the precordial area. During these observations the greater part of the sternum should be alternately raised and lowered.

The chief part of the sternum is now to be removed, along with whatever costal cartilages are connected with it. On the side on which the cartilages remain in connection with the bone the triangularis sterni and the internal mammary vessels are to be dissected from behind. The chondro-sternal joints may be dissected at this stage, or it may be convenient to preserve the sternum for their future dissection.

Phrenic Nerves, Pleuræ, Pericardium, and Lungs.—Before the further stages of the dissection are entered upon, it is necessary that the dissector should have some knowledge of the general position of the structures to be exposed. From their complicated nature it is not possible to lay down hard-and-fast directions, and in his mode of procedure he must keep a careful look-out.

The phrenic nerve is to be dissected, and its close relation to the pericardium is to be noted, as well as its course in front of the root of the lung. Possibly the superior phrenic branch (comes nervi phrenici) of the internal mammary artery may be found coming into contact with the nerve high up in the thorax. The reflections of the pleura are to be studied both in the transverse and in the vertical directions. If any adhesions are present, these should be separated with the fingers, and any fluid which has accumulated must be

removed, and the parts thoroughly cleansed. The lines of the sternal and costo-diaphragmatic reflections of the pleura are to be carefully studied. In examining the antero-posterior reflections of the membrane the ligamentum latum pulmonis, below the root of the lung, is to be noted, and the mediastinum thoracis, with its divisions, is to receive very careful attention, these divisions being anterior, superior, middle, and posterior. The two pleural sacs which form the lateral boundaries of the anterior mediastinum are to be separated, when the middle mediastinum will be exposed, with the pericardium, enclosing the heart, lying in it.

The lungs are next to be studied. They have been already examined in their inflated and collapsed conditions, but attention is now to be directed to their form, component parts, fissure or fissures, and lobes. The differences between the two lungs are also to be noted, which impress corresponding differences upon the pleural sacs. The roots of the lungs are not to be dissected at this stage.

The superior mediastinum should now be examined, without disturbing the pericardium, and the remains of the thymus body, together with the superior mediastinal glands, are to be dissected.

The right and left innominate veins are next to receive attention, and their inferior thyroid and internal mammary tributaries, with, in some cases, the first intercostal vein, are to be noted. The left superior intercostal vein is to be displayed as an additional tributary of the left innominate vein, which it joins not far from its commencement, after having crossed the back part of the arch of the aorta.

The superior vena cava, formed by the junction of the two innominate veins, is to be shown and followed down to where it pierces the pericardium, but no farther in the meantime. The right azygos vein is to be displayed arching over the root of the right lung, and opening into the superior vena cava just before that vessel pierces the pericardium.

The pericardium is now to be studied from the exterior. Connected with its anterior wall parts of the superior and inferior sterno-pericardial ligaments of Luschka are to be looked for. The relation of the fibrous portion of the pericardium to the diaphragm is to be looked to, and its disposition upon the great vessels at the base of the heart, for which it forms sheaths, is to receive attention.

The intimate relation of the phrenic nerves to the pericardium has been already noted. The pericardium is now to be laid open by means of a vertical median incision, extending over its entire length, and a transverse incision opposite the roots of the lungs. The serous portion of the pericardium is then to receive careful attention. It is to be observed that, being a serous membrane, it is composed of parietal and visceral portions, which enclose between them a shut sac. The close relation of the parietal portion to the fibrous part is to be noted, and the disposition of the visceral portion upon the ascending aorta and trunk of the pulmonary artery is to be carefully studied. It will be seen to form a single sheath for them, and to rise upon the ascending aorta for from 1 to 1½ inches. The transverse sinus of the pericardium should be explored with the finger. It will be found lying behind the ascending aorta and trunk of the pulmonary artery, and in front of the auricular portion of the heart. In connection with the serous portion of the pericardium the triangular fold, called the vestigial fold of Marshall, is to be looked for in front of the root of the left lung, between the left pulmonary artery and the subjacent pulmonary vein. When this fold is carefully dissected it will be found to contain a delicate fibrous cord, which is a vestige of the left duct of Cuvier of embryonic life.

The pericardium is now to be removed, which will show the lower part of the superior vena cava. The heart, being now exposed, should receive the most careful attention. Its external form and component parts are to be observed, and the relations of these parts to the thoracic wall must be thoroughly mastered. More especially the relation of the valvular orifices of the heart to the thoracic wall calls for the closest observation. The trunk of the pulmonary artery is to be studied, as it springs from the conus arteriosus

at the base of the right ventricle, and it is to be noted that it conceals the origin of the aorta from the base of the left ventricle. Further, it will be seen that both of these vessels are embraced by the auricular appendices.

The right and left coronary arteries, each accompanied by the corresponding coronary plexus of nerves, are to be displayed as they come forwards on either side of the root of the pulmonary artery. The superior vena cava is to be shown opening into the postero-superior angle of the right auricle, and, by raising the heart, the inferior vena cava will be seen to open into the postero-inferior angle of the right auricle. The four pulmonary veins, two right and two left, will be found to open into the back part of the left auricle.

The ascending aorta is to be dissected, and in conjunction with it the trunk of the pulmonary artery, the superior vena cava being also kept in view. The arch of the aorta is next to be dissected, along with the innominate artery, and the thoracic portions of the left common carotid and left subclavian arteries.

Crossing in front of the aortic arch will be found the left phrenic and left pneumogastric nerves, and between them the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, both of these two small nerves being on their way to the superficial cardiac plexus.

The left recurrent laryngeal nerve is to be shown arising from the left pneumogastric opposite the lower margin of the arch of the aorta, and passing backwards beneath the arch, and then upwards behind it, where it gives off one or two cardiac branches to the deep cardiac plexus. The left superior intercostal vein will be seen crossing over the back part of the arch on its way to the left innominate vein.

Within the concavity of the arch, in addition to the left recurrent laryngeal nerve, the superficial cardiac plexus of nerves and the ligamentum ductûs arteriosi fall to be dissected. The superficial cardiac plexus lies in front of the trunk of the pulmonary artery, close to its bifurcation, and on the right side of the ligamentum ductûs arteriosi, and it requires the most careful dissection. The best way to proceed is to follow downwards from the front of the arch of the aorta the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, both of which will conduct to the plexus. In this plexus a small ganglion, called the ganglion of Wrisberg, is to be looked for. The plexus itself will be found to furnish delicate filaments to the left anterior pulmonary plexus, after which it is prolonged into the right coronary plexus, which latter is reinforced by fibres from the right half of the deep cardiac plexus. The ligamentum ductûs arteriosi will be found extending from the root of the left pulmonary artery to the under aspect of the arch of the aorta immediately beyond the place of origin of the left subclavian artery.

The left lung is now to be turned well forwards, and fixed in that position by hooks. The trunk of the left pneumogastric nerve is to be followed downwards behind the root of the left lung. Before reaching that point it is to be shown furnishing a few branches which pass to the front of the root, and there form the small anterior pulmonary plexus. Behind the root of the left lung the nerve will be found to become flattened, and to break up into a number of branches, which form the posterior pulmonary plexus. From this plexus the nerve is to be shown issuing as two cords which pass downwards to the œsophagus, where they are to be left in the meantime. The right pneumogastric nerve will be found behind the right innominate vein, and on the right side of the right innominate artery and trachea. A little above this point the nerve has crossed over the first part of the right subclavian artery, and parted with the right recurrent laryngeal nerve opposite the lower margin of that vessel. The right pneumogastric nerve will be seen to occupy a much deeper position than the left. A branch to the deep cardiac plexus should be looked for coming from it, and the main nerve is to be followed downwards behind the root of the right lung, that organ having been turned well forwards, and kept in that position by hooks. Behind the root of the right lung the right pneumogastric nerve acts in a manner similar

to the left nerve, and forms the right posterior pulmonary plexus, from which it emerges as two cords, and these, as on the left side, descend to the œsophagus.

The lungs having been replaced in position, the root of each is now to be fully dissected, the bronchus, pulmonary artery, and pulmonary veins being clearly separated from each other all round the root. In performing this dissection the anterior and posterior pulmonary plexuses of nerves, already referred to, are to be studied, and the bronchial lymphatic glands are to be displayed. These glands are usually quite black, this being due to the deposit of carbonaceous matter in them. The general relations of each root, and the special relations of the chief constituents, are to be thoroughly mastered.

The right and left pulmonary arteries should now be examined from their origin from the main trunk to the root of each lung, and their relations are to be noted, as well as the ligamentum ductûs arteriosi in connection with the root of the left pulmonary artery. The pulmonary veins on each side are also to be followed from the root of the lung to the back part of the left auricle of the heart. In the dissection of the roots of the lungs the bronchial arteries, one right and two left, and the bronchial veins are to be kept in view.

Exterior of the Heart.—The dissection of the heart is now to be proceeded with. Its external form is to be carefully examined; the directions of the base, apex, and borders are to be observed; and the grooves by which it is divided into auricular and ventricular portions, and these, in turn, into right and left auricles, and right and left ventricles, are to be noted. The apex will be seen to be formed entirely by the left ventricle.

The right and left coronary arteries are to be fully dissected, and their origins from the root of the ascending aorta clearly shown, the trunk of the pulmonary artery being displaced as may be required. The right coronary artery is to be followed along the front and back of the right auriculo-ventricular groove, and its marginal branch is to be shown passing along the margo acutus. On the back of the heart the main vessel will be found to divide into two terminal branches, transverse and descending. The transverse branch is to be followed into the back part of the left auriculo-ventricular groove, where it anastomoses with the transverse branch of the left coronary artery; and the descending branch is to be followed along the inferior interventricular groove as far as the region of the apex, where it anastomoses with the descending branch of the left coronary artery.

The left coronary artery is to be shown dividing very early into a transverse and descending branch on the left side of the root of the pulmonary artery. The transverse branch is to be followed round the left auriculo-ventricular groove, and its marginal branch is to be shown passing along the margo obtusus vel rotundus. The descending branch is to be followed along the antero-superior interventricular groove as far as the region of the apex.

In dissecting the coronary arteries the right and left coronary plexuses of nerves are to be kept in view, and the various cardiac veins are to be at the same time displayed.

In the back part of the left auriculo-ventricular groove the coronary sinus, about 1 inch long, will be found, and its dilated condition is to be noted. The great cardiac or coronary vein (anterior interventricular vein) will be found in the antero-superior interventricular groove, along with the descending branch of the left coronary artery. On entering the front part of the left auriculo-ventricular groove (where it is now strictly the great cardiac or coronary vein), it should be followed, in company with the transverse branch of the left coronary artery, to the back part of the groove, where it will be found to become continuous with the coronary sinus. The middle cardiac vein (posterior interventricular vein) will be met with in the inferior interventricular groove, where it accompanies the descending branch of the right coronary artery, and it should be shown to join the right extremity of the coronary sinus. The right or small cardiac or coronary vein will be

found in the back part of the right auriculo-ventricular groove, and, it may be, in the front part of it. The anterior cardiac veins will be found on the front of the right ventricle and along the margo acutus, and they are to be traced to the right coronary vein. The posterior cardiac veins will be found on the inferior surface of the left ventricle, and they are to be followed to the lower border of the coronary sinus. The oblique vein of Marshall is to be carefully looked for on the back of the left auricle, along which it passes downwards and inwards to open into the left extremity of the coronary sinus. The tributaries of this sinus are now to be fully reviewed, and thereafter it is to be laid open with scissors. This will bring into view a valve, composed of two segments, which is situated at the place where the great cardiac or coronary vein opens into the sinus, namely, about 1 inch from the ending of the sinus in the right auricle.

The very delicate nerves derived from the coronary plexuses course upon the surfaces of the ventricles, but in the human heart they do not lend themselves very readily to inspection. The heart of the calf is much more favourably disposed for their examination.

Interior of the Heart.—In this dissection the best way to proceed is to follow the course of the blood through the heart. The right auricle is to be laid open by two incisions as follows: (1) a vertical incision is to be made from the auricular extremity of the superior vena cava to near the point of entrance of the inferior vena cava, keeping clearly in front and to the left of it, in order not to injure the vestigial Eustachian valve which is associated with its orifice; and (2) an oblique incision is to be made from the auricular appendix to about the centre of the vertical incision. Having removed the venous blood and sponged the interior of the auricle, the following points are to receive attention: (1) the musculi pectinati, situated on the wall of the auricular appendix and the adjacent portion of the right wall of the atrium; (2) the crista terminalis; (3) the fossa ovalis and annulus ovalis on the inter-auricular septum; (4) the so-called tubercle of Lower; (5) the vestigial Eustachian valve in connection with the orifice of the inferior vena cava; (6) the opening of the coronary sinus, and the Thebesian valve; (7) the foramina Thebesii; and (8) the auriculo-ventricular orifice. It is to be noted that no valve guards the opening of the superior vena cava.

In connection with the annulus ovalis a very minute opening may be found under cover of it, leading into the left ventricle. Its possible presence may be determined by exploring with a fine probe. Three fingers, held side by side, should be passed through the auriculo-ventricular orifice, and, if normal, it will be found to admit them readily.

The right ventricle is to be opened by means of two incisions, the left forefinger having previously been passed through the auriculo-ventricular orifice. A transverse incision is to be carried along the upper part of the ventricle, just below and parallel to the auriculo-ventricular groove. This incision is to be prolonged as far as a point below the root of the pulmonary artery. The other incision is to commence at the left end of the foregoing incision, and is to be carried downwards just to the right of the antero-superior inter-ventricular groove. In this manner a triangular flap, representing the front wall of the right ventricle, can be turned down, and the cavity fully exposed. The second incision, just stated, may be replaced by one extending along the margo acutus to the lower end of the antero-superior interventricular groove, and then a triangular flap would be raised towards the left.

After cleansing the ventricle, the dissector is to observe (1) that its cavity is excluded from the apex of the heart, (2) that it is prolonged to the root of the pulmonary artery as the infundibulum or conus arteriosus, and (3) that the interventricular septum bulges into it, so as to be convex on its right aspect. The fleshy elevations, called columnæ carneæ, are to receive attention, their various kinds are to be noted, and special attention is to be given to the variety known as the musculi papillares. These latter will be found to be disposed in two groups—anterior and posterior. The absence of columnæ carneæ from the infundibulum is to be noted, and the moderator band is to be looked for extending from the anterior papillary muscle to the interven-

tricular septum. The tricuspid valve is next to receive attention, and its three main segments are to be carefully studied, the small secondary segments lying between their basal parts being noted. The chordæ tendineæ and their relations to the segments of the tricuspid valve should be closely examined, and the function of that valve is to receive careful consideration. The study of the pulmonary valve, which guards the orifice of the pulmonary artery, is to be postponed till a later period.

On account of the posterior position of the left auricle, and preparatory to opening it, the inferior vena cava may be divided in order to liberate the heart from the diaphragm. The heart is then to be turned over to the right side, and also upwards. A transverse incision may then be made above and parallel to the auriculo-ventricular groove, and any other which may suggest itself to the dissector, who is supposed to know by previous study the internal arrangement of the parts. The interior having been cleansed, it will be at once apparent that the musculi pectinati are confined entirely to the region of the auricular appendix. On examining the left surface of the interauricular septum the position of the foramen ovale of the fœtal heart, and the remains of the valve which originally closed it, will be recognised as a slight depression, which is limited inferiorly by a crescentic border with the concavity directed upwards. It may be compared to the imprint of a finger-nail.

The orifices of the pulmonary veins on the posterior wall—two right and two left—are to be examined, and the absence of valves noted. The left auriculo-ventricular orifice is next to receive attention. If two fingers, held side by side, are passed through the orifice, it will be found, if normal, to admit them readily.

The left ventricle is to be opened by two incisions, one carried transversely across the ventricle, just below and parallel to the auriculo-ventricular groove, and the other extending from the right end of the preceding incision to the lower part of the ventricle on the left side of the apex. The ventricle having been cleansed, the great thickness of its wall is to be noted, and the dissector is to observe (1) that its cavity extends quite to the apex of the heart, and (2) that the interventricular septum recedes from it, so as to be concave on this aspect. The portion of the cavity adjacent to the aortic orifice is to receive attention, this part, which is known as the aortic vestibule of Sibson, having fibrous walls. The columnæ carneæ and their varieties are to be studied as on the right side, their very intricate arrangement being noted, and special attention is to be directed to the musculi papillares, which are anterior and posterior. The two large cusps of the mitral valve, with two small cusps placed between their basal parts, are to be carefully studied, and the relation of the anterior or aortic cusp to the aortic orifice is to be noted. The chordæ tendineæ, and their relations to the segments of the valve, should be closely examined, and the function of the valve is to receive careful consideration. The auriculo-ventricular and aortic orifices are to be studied, but the aortic valve is to be left over for future consideration. Before leaving the study of the interior of the heart, the relations of its auriculo-ventricular and arterial valvular orifices to the thoracic wall should be thoroughly mastered.

Deep Cardiac Plexus.—To expose this plexus the ascending aorta should be divided near its upper end, and the superior vena cava is to be divided a little below the point where it receives the right azygos vein. The arch of the aorta is then to be displaced towards the left side, and kept out of the way by hooks. If necessary, the ligamentum ductûs arteriosi should be divided, but the superficial cardiac plexus is to be left intact. This dissection will expose the thoracic portion of the trachea, in front of which the deep cardiac plexus is situated, just above the bifurcation into the two bronchi. By very careful dissection the nerves forming this plexus are to be shown passing downwards and inwards on the sides of the trachea to its anterior aspect, where they end in the plexus. The deep cardiac plexus is arranged in two halves, right and left, which are in free communication with each other. The contributory nerves to the right half of the plexus are

(1) the upper, middle, and lower cervical cardiac branches of the right sympathetic; (2) the upper and lower cervical cardiac branches of the right pneumogastric; (3) one or two branches from the right recurrent laryngeal nerve; and (4) one or two thoracic cardiac branches from the right pneumogastric nerve. The contributory nerves to the left half of the plexus are (1) the middle and lower cervical cardiac branches of the left sympathetic; (2) the upper cervical cardiac branch of the left pneumogastric; and (3) branches from the left recurrent laryngeal nerve. As regards the upper cervical cardiac branch of the left sympathetic, and the lower cervical cardiac branch of the left pneumogastric, they have already been followed over the arch of the aorta into its concavity, where they have been seen to form the superficial cardiac plexus. The connection between the two halves of the deep cardiac plexus is to be made out, as well as that between the right half and the superficial cardiac plexus. The right coronary plexus is to be shown coming from the superficial and right half of the deep cardiac plexus. From the right half of the deep cardiac plexus branches are to be looked for passing to the right anterior pulmonary plexus, and also to the right auricle. The left coronary plexus is to be shown coming from the left half of the deep cardiac plexus, of which it forms the chief prolongation. Branches are also to be looked for passing to the left anterior pulmonary plexus, and to the left auricle.

The heart is now to be removed by dividing the trunk of the pulmonary artery and the pulmonary veins. The aorta and pulmonary artery are, in succession, to be attached to a water-tap, and by turning the stop-cock the flow of water will demonstrate the action of the arterial valves. The three bulgings on the exterior of each vessel close to the corresponding ventricle, and produced by the sinuses of Valsalva in the interior, will be at the same time shown. The auricular portion of the heart should now be separated from the ventricular portion. There is no continuity between the auricular and ventricular muscular fibres, these being only connected through the medium of the fibrous rings round the auriculo-ventricular orifices. A heart usually requires to be boiled in the first place, in order to dissolve the fibrous tissue, but the separation of the auricular from the ventricular portion is possible by careful dissection. After its completion an instructive view will be obtained of the orifices at the base of the ventricular portion. The auriculo-ventricular orifices will be seen to lie side by side, the aortic orifice being in front of and between them, and the pulmonary orifice being in front of the aortic. In the angle between the auriculo-ventricular and aortic orifices a collection of dense fibrous tissue, of the consistence of cartilage, will be found, and processes are to be shown passing from it to the fibrous rings which surround the auriculo-ventricular and aortic orifices.

The pulmonary artery is next to be laid open by an incision passing between two of the three segments of which the pulmonary valve is composed. The segments of the valve and the sinuses of Valsalva are to be examined, but these admit of much better observation in the case of the aortic valve. The aorta is also to be laid open, observing the same precaution as in opening the pulmonary artery, and the segments of the aortic valve are to receive most careful attention. The two lunulæ and corpus Arantii of each segment are to be noted, the direction of the free margins of the segments is to be observed, and the sinuses of Valsalva are to be looked to. The orifices of the right and left coronary arteries are to be examined, that of the right being connected with the right antero-lateral sinus of Valsalva, and that of the left with the left antero-lateral sinus of Valsalva. Lastly, the function of the aortic and of the pulmonary valves is to be carefully studied.

For the purpose of examining the arrangement of the muscular fasciculi of the auricles and ventricles a sheep's heart may be obtained and boiled for a short time in order to dissolve the fibrous tissue.

Posterior Mediastinum.—The thoracic part of the trachea is now to be dissected, and its bifurcation into two bronchi, right and left, is to be shown, as well as some bronchial glands which lie within the angle of bifurcation. The greater size of the right bronchus and the greater length of the left

bronchus are to be observed, and it is to be specially noted that the right bronchus is more in line with the trachea than the left. The trachea is then to be carefully divided a little above its bifurcation, and the lower part of it, with the two bronchi and two lungs, is to be removed. The right bronchus is to be dissected, and its eparterial and hyparterial divisions are to be shown. The ramifications of the bronchial tubes within the lungs are then to be followed out.

The difference between the main bronchus and its pulmonary ramifications, as regards the extent of the cartilaginous rings in their walls, should attract attention. The bronchial tubes are to be laid freely open, and their mucous lining is to be inspected. The lung is also to be incised at different parts, and the cut surfaces examined. A portion of healthy lung should be put into a dish of water, and the result should be noted.

The thoracic part of the œsophagus is next to be displayed. The dissector is to note that it lies at first on the right side of the descending aorta, then in front of it, and finally slightly to its left side. The right and left pneumogastric nerves will be found in very close contact with the gullet, the right nerve gradually inclining from the right side of the tube to its posterior aspect, and the left nerve gradually inclining from the left side of the tube to its anterior aspect. The plexus gulæ, formed by branches of these two nerves, should be displayed, and the œsophageal branches of the descending aorta are to be borne in mind.

The œsophagus is to be displaced, and the thoracic duct is to be dissected. The dissectors should remember that this duct is sometimes double in the thorax. It will be found lying close to the right side of the descending aorta, between it and the right azygos vein. It is to be carefully followed up beneath the arch of the aorta and along the left side of the œsophagus, on its way to the root of the neck on the left side. The dissectors of the thorax should now associate themselves with the dissectors of the head and neck, in order to follow the thoracic duct to its termination in the angle of junction between the left internal jugular and left subclavian veins.

The descending aorta falls to be dissected next, along with its branches. The aortic intercostal arteries are to be shown on either side, and they are to be followed into the back parts of the intercostal spaces. At this stage the dissector should display the delicate posterior intercostal aponeurosis between which and the parietal pleura each intercostal artery passes. The corresponding intercostal vein and nerve are to be shown in position, and near the angle of the rib the aortic intercostal artery will be found to give off its collateral intercostal branch, having previously, on its entrance into the space, given off its dorsal branch. In dissecting the descending aorta the bronchial arteries which nourish the lungs are to be looked for behind the corresponding bronchus. There is usually one right bronchial artery, which arises either from the descending aorta or from the first right aortic intercostal artery, and there are two left bronchial arteries, which spring from the parent trunk.

The azygos veins are next to receive attention. The right azygos vein will be found under cover of the œsophagus, where it has the thoracic duct on its left side, and it is to be followed up to its termination in the superior vena cava, a tag of which vessel has been specially preserved. The following tributaries are to be shown entering the right azygos vein: (1) the lower seven, or it may be eight, right intercostal veins; (2) the lower and upper transverse azgyos veins; and (3) the right superior intercostal vein, which takes up the second and third, and it may be the fourth, intercostal veins of the right side. The first right intercostal vein opens into the corresponding innominate vein, or sometimes into the vertebral vein. The lower and upper left azygos veins are then to be dissected, along with the lower and upper transverse azygos veins; and the left superior intercostal vein, if not previously dissected, is to be followed over the back part of the arch of the aorta, and shown entering the left innominate vein. The first left intercostal vein is disposed similarly to its fellow of the right side.

The superior intercostal artery on either side is to be dissected, and its

distribution to the first and seond intercostal spaces shown. The vessel will be found descending in front of the neck of the first rib. A branch from the first aortic intercostal artery—that, namely, to the third space—should be looked for ascending over the neck of the third rib to join the second intercostal artery, which it sometimes replaces.

The thoracic portion of the gangliated cord of the sympathetic should now be dissected. It will be found lying over the heads of the ribs under cover of the parietal pleura, and gradually inclining inferiorly on to the side of the vertebral column. Two rami communicantes are to be shown passing between each ganglion and the adjacent intercostal nerve, and it is to be noted that these rami are very short. The vascular branches of distribution of the upper ganglia, as well as the branches to the posterior pulmonary plexus of nerves, are not easy of dissection, but the splanchnic nerves admit of this readily, the great and small splanchnic nerves being constant, but the least being frequently absent.

The upper surface of the diaphragm is next to be dissected, and attention should be directed to (1) its thoracic relations, (2) the central tendon, (3) the foramen quadratum, (4) the aortic and œsophageal openings, and (5) the relation of the sympathetic cords and splanchnic nerves to it. The diaphragm may now be laid open, in association with the dissectors of the abdomen, and the thoracic duct is then to be followed down to its commencement in the receptaculum chyli. Thereafter the subcostal muscles should be dissected. They will be found over the back parts of the ribs in the vicinity of the angles.

Articulations.—1. **Vertebral Column.**—The part available for the dissection of the ligaments is the portion below the first thoracic vertebra, and probably as low as the tenth or eleventh thoracic vertebra. The ligaments to be dissected are (1) the anterior common ligament, which is easily displayed; (2) the posterior common ligament, to show which the neural arches of the vertebræ must be removed by sawing through the pedicles; (3) the intervertebral discs, which are to be dissected by means of transverse and vertical sections; (4) the ligamenta subflava, which connect the laminæ, and are readily seen after removal of the neural arches; (5) the capsular ligaments, which connect the articular processes; (6) the supraspinous and interspinous ligaments; and (7) the intertransverse ligaments.

The movements of the vertebral column are to be carefully studied.

2. **Ribs—Costo-central Joints.**—The ligaments to be dissected are (1) the anterior costo-central or stellate, easily recognised; and (2) the interarticular, which is only seen on opening the joint, and which is absent in the first, sometimes the tenth, the eleventh, and twelfth joints. The two synovial cavities are to be noted, except in the case of the joints just enumerated as having no interarticular ligament.

Costo-transverse Joints.—The ligaments to be dissected are the posterior, middle, and superior costo-transverse. Within the posterior costo-transverse ligament the synovial membrane of the joint is to be shown. The middle costo-transverse or interosseous ligament can only be studied properly by sawing horizontally through the neck of the rib and the adjacent transverse process. The superior costo-transverse ligaments are to be displayed as two distinct bands—anterior or external, which is large; and posterior or internal, which is small. The continuity of the outer border of the anterior ligament with the posterior intercostal aponeurosis is to be shown.

Costo-chondral Joints.—Each rib is connected to its cartilage by the continuity which takes place between the periosteum of the rib and the perichondrium of the cartilage.

Sterno-chondral Joints.—The ligaments to be dissected are anterior, posterior, superior, and inferior. In the case of the second joint, and it may be in some of the succeeding joints, there is an interarticular ligament, which divides the joint into two distinct synovial compartments. The direct connection of the first costal cartilage with the manubrium sterni is to receive attention.

Interchondral Joints.—These are met with from about the fifth to the

ninth or tenth costal cartilages. They are provided with capsular ligaments and synovial membranes.

3. **Sternum.**—The manubrium and body are connected by ligamentous fibres, disposed longitudinally in front and behind, and by a plate of fibro-cartilage which is interposed between the articular surfaces. It is to be noted that the entire sternum is strengthened by its dense periosteum, by the radiating fibres of the chondro-sternal ligaments, and by the tendinous fibres of origin of the pectoralis major muscles.

The movements of the ribs are to be studied with the greatest care, and the muscles concerned in these movements are to be specially noted.

THE HEAD AND NECK

BACK OF THE SCALP AND NECK

Landmarks.—The external occipital protuberance can, as a rule, readily be made out, and the superior curved line, if well developed, may be felt extending outwards from it. The mastoid process of the temporal bone can be distinguished without difficulty behind the auricle. The occipital artery, with the great occipital nerve on its inner side, lies a little internal to the centre of a line connecting the external occipital protuberance and the tip of the mastoid process. The occipital lymphatic gland, or glands, may be felt, when enlarged, over the upper part of the trapezius or complexus muscle. The spine of the seventh cervical vertebra, or vertebra prominens, can easily be felt, and that of the sixth may also be made out. Extending from the external occipital protuberance to the seventh cervical spine there is an elongated depression, called the **nuchal furrow,** which indicates the position of the ligamentum nuchæ. It is possible to feel the strong bifid spine of the axis by sinking the finger deeply into the upper part of the nuchal furrow, near the occipital bone, but the spines of the third, fourth, and fifth cervical vertebræ lie too deeply for detection. The lymphatic glands, known as the **glandulæ concatenatæ,** may be felt, when enlarged, along the posterior border of the sterno-cleido-mastoid muscle.

Back of the Neck—Fasciæ.—The superficial fascia presents nothing worthy of note. The deep fascia closely invests the cervical portion of the trapezius, and is then prolonged over the posterior triangle of the neck to the posterior border of the sterno-cleido-mastoid, where it divides to ensheathe that muscle. It will be described in connection with the deep cervical fascia.

Nerves.—The nerves of this region are as follows: the great occipital; the least or third occipital; the internal branches of the posterior primary divisions of the third, fourth, and fifth cervical spinal nerves; the small occipital; the great auricular; the superficial cervical; the spinal accessory; and the descending superficial branches of the cervical plexus, namely, the suprasternal, supra-clavicular, and supra-acromial.

The **great occipital nerve** is the internal branch of the posterior primary division of the second cervical nerve. It pierces the upper part of the complexus muscle, and sometimes the trapezius, about ½ inch from the middle line. It then turns upwards, with an inclination outwards, and accompanies the occipital artery to the cranial integument, lying on the inner side of that vessel. Its branches are long, and have an extensive distribution, reaching as far as the vertex of the skull. Externally it communicates with the small occipital nerve, and internally with the least occipital.

The **least** or **third occipital nerve** is a small offset from the internal branch of the posterior primary division of the third cervical nerve. Having pierced the trapezius, it ascends internal to the great occipital nerve, with which it communicates, and has a limited distribution to the occipital integument inside that nerve.

The **internal branches of the posterior primary divisions of the third, fourth, and fifth cervical nerves** appear through the trapezius close to the middle line, and turn outwards to supply the skin of the back of the neck, that of the third furnishing, as just stated, the least occipital nerve.

The **small occipital nerve** is one of the ascending superficial branches of the cervical plexus, and arises from the anterior primary division of the second cervical nerve, sometimes receiving a branch from that of the third. It appears at the posterior border of the sterno-cleido-mastoid muscle, and ascends along that border to the occipital region. Here it divides into mastoid and occipital branches, which supply the skin of the mastoid, outer part of the occipital, and adjacent portion of the parietal, regions. It furnishes an auricular branch to the skin of the inner surface of the auricle, and it communicates with the great occipital, the mastoid and auricular branches of the great auricular, and the posterior auricular branch of the facial. The small occipital nerve is sometimes double, and in these cases one portion of it usually pierces the anterior border of the trapezius.

The **great auricular nerve,** like the small occipital, is one of the ascending superficial branches of the cervical plexus, and arises by two roots from the anterior primary divisions of the second and third cervical nerves. It turns round the posterior border of the sterno-cleido-mastoid immediately below the small occipital nerve, and passes upwards and forwards upon that muscle towards the lobule of the auricle, on approaching which it divides into mastoid, auricular, and facial branches. The *mastoid branch* is distributed to the skin over the mastoid region; the *auricular branch* supplies the skin of the inner surface of the auricle, and sends one or two twigs through the cartilage of the auricle to the skin covering its outer surface; and the *facial branch* is distributed to the skin over the parotid gland. The mastoid and auricular branches communicate with the small occipital and posterior auricular nerves, and the facial branch communicates in the parotid gland with the cervico-facial division of the facial nerve.

The **superficial** or **transverse cervical nerve,** like the small occipital and great auricular, is a superficial branch of the cervical plexus, and arises by two roots from the anterior primary divisions of the second and third cervical nerves. It appears at the posterior border of the sterno-cleido-mastoid, close below the great auricular,

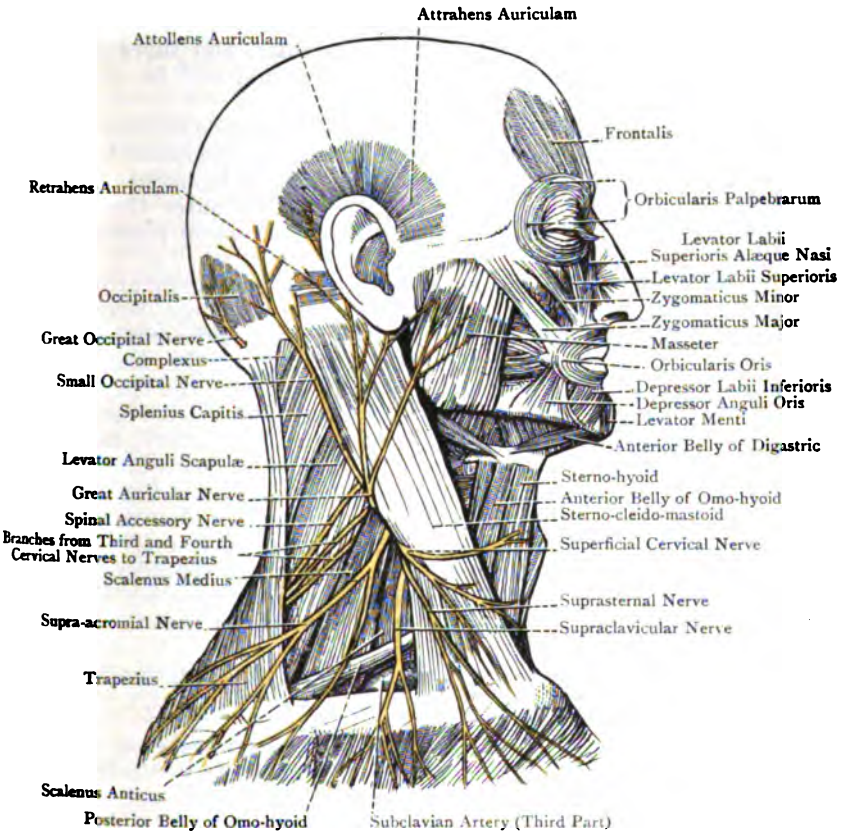


FIG. 418.—THE RIGHT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed, and the Nerves are shown).

and turns over that muscle to reach the front of the neck, where it will be afterwards described.

The **spinal accessory nerve** (*spinal portion*) appears at the posterior border of the sterno-cleido-mastoid near its centre, below the superficial cervical, and then crosses the posterior triangle of the neck downwards and backwards to the anterior border of the trapezius, beneath which it passes. It is accompanied by two small branches

of the anterior primary divisions of the third and fourth cervical nerves, which lie below it, and it forms a plexiform communication with them beneath the trapezius, to which muscle it is distributed.

The **descending superficial branches of the cervical plexus** appear at the posterior border of the sterno-cleido-mastoid, below the spinal accessory, usually as a single trunk which arises by two roots from the anterior primary divisions of the third and fourth cervical nerves. This trunk, as it descends, divides into three nerves, namely, **suprasternal, supraclavicular,** and **supra-acromial,** which pass downwards over the clavicle, and will be afterwards referred to.

Muscles—Cervical Portion of the Trapezius—*Origin.*—(1) The inner third of the superior curved line of the occipital bone, and the external occipital protuberance ; and (2) the ligamentum nuchæ.

Insertion.—(1) The posterior border of the outer third of the clavicle ; and (2) the inner border of the acromion process of the scapula.

Nerve-supply.—(1) The spinal accessory nerve (spinal portion); and (2) branches from the cervical plexus, which are derived from the anterior primary divisions of the third and fourth cervical nerves. The nerves enter the deep surface of the muscle after passing beneath its anterior border a little above the clavicle, and they here form a plexiform communication with each other.

Blood-supply.—There is one specially named artery, called the **superficial cervical artery,** which is a branch of the transverse cervical, and, like the nerves, enters the deep surface of the muscle.

The fibres are directed downwards, forwards, and outwards.

Action.—The cervical fibres, acting from their origin, elevate the outer end of the clavicle and the point of the shoulder. Acting from their insertion they extend the head, and incline the neck towards the same side, the face being directed towards the opposite side.

The anterior border of the muscle forms the posterior boundary of the posterior triangle of the neck.

Occasionally a small muscle, called the **transversus nuchæ,** is met with, extending from the external occipital protuberance to the tendon of insertion of the sterno-cleido-mastoid. It may be fleshy or tendinous.

Ligamentum Nuchæ.—This is a strong fibrous band which occupies the median line of the neck. Its superficial fibres are attached superiorly to the external occipital protuberance, and inferiorly to the spine of the seventh cervical vertebra. Its deep fibres are attached to the external occipital crest, and to the spines of cervical vertebræ, from the second to the sixth inclusive. They also extend into the interspinous intervals, between the interspinales muscles, where they represent interspinous ligaments.

Insertion and Posterior Border of the Sterno-cleido-mastoid.—This muscle is inserted into (1) the outer surface of the mastoid process of the temporal bone, and (2) the superior curved line of

the occipital bone over about its outer half, or more. The posterior border of the muscle forms the anterior boundary of the posterior triangle of the neck, and has the following nerves related to it: (1) the small occipital ascends along it to the head; (2) the great auricular passes upwards and forwards over it towards the lobule of the auricle; (3) the superficial cervical crosses it in a forward direction; (4) the spinal accessory appears from behind it, along with the branches of the third and fourth cervical nerves to the trapezius; and (5) the descending superficial branches of the cervical plexus emerge from underneath it.

The **glandulæ concatenatæ** belong to the deep cervical glands, and are situated along the posterior border of the sterno-cleido-mastoid muscle. They will be afterwards described.

The levator anguli scapulæ, rhomboids, serratus posticus superior, splenius, complexus, transversalis cervicis, trachelo-mastoid, semi-spinalis colli, intertransversales, and interspinales muscles will be found described in connection with the muscles of the back, see p. 268 *et seq.*

Second and Third Parts of the Occipital Artery.—At the mastoid process this vessel lies very deeply. Having crossed the rectus capitis lateralis muscle, it enters the occipital groove on the inner aspect of the mastoid process, where it is covered by the following structures, in order from the surface downwards: (1) sterno-cleido-mastoid; (2) splenius capitis; (3) trachelo-mastoid; (4) mastoid process; and (5) the posterior belly of the digastric. In its backward course the vessel rests, in succession, upon the insertions of the obliquus capitis superior and complexus, and it escapes from beneath the muscles covering it in the following order: posterior belly of the digastric, trachelo-mastoid, splenius capitis, and sterno-cleido-mastoid. After emerging from beneath the last-named muscle, it lies for a little in the posterior triangle, close to the apex, and then, piercing the occipital origin of the trapezius, it enters upon the third part of its course. This part ascends, along with the great occipital nerve, to the occipital region, where it divides into several long tortuous branches.

Branches.—The branches of the second and third parts are as follows: mastoid, posterior meningeal, arteria princeps cervicis, communicating, muscular, and terminal. The **mastoid artery** passes through the arterial fissure on the outer surface of the mastoid process, and supplies the diploë and mastoid cells, as well as the adjacent dura mater. The **posterior meningeal artery** enters the cranial cavity through the jugular foramen, and takes part in the supply of the dura mater of the posterior fossa. The **arteria princeps cervicis** arises under cover of the splenius capitis, and at the outer border of the complexus it divides into a superficial and deep branch. The *superficial branch* is distributed to the splenius capitis and trapezius, and anastomoses, in the latter muscle, with the superficial cervical artery. The *deep branch* passes beneath the complexus, and anastomoses, upon the semispinalis

colli, with (1) the deep cervical of the superior intercostal of the second part of the subclavian, and (2) branches of the vertebral artery. The **communicating branches** enter the suboccipital triangle, where they anastomose with branches of the vertebral artery. The **muscular branches** supply the contiguous muscles. The **terminal branches** are at first two in number, but these soon divide into several long tortuous branches, which supply the occipitalis and the integument as high as the vertex. They anastomose with the posterior auricular, the posterior division of the superficial temporal, and their fellows of the opposite side.

The **occipital venous plexus** communicates with the posterior auricular, and the posterior branch of the superficial temporal, veins. It receives the *parietal emissary vein*, which emerges through the parietal foramen, and so a communication is established with the superior longitudinal sinus. Sometimes it receives a small *occipital emissary vein*, which emerges through an opening at the external occipital protuberance, and then a communication would be established with the torcular Herophili.

Two or three **occipital veins** emerge from the occipital plexus. The external vessel is known as the **posterior jugular vein.** It receives the *mastoid emissary vein*, which emerges through the mastoid foramen, and so an important communication is established with the lateral sinus. Having been reinforced by tributaries from the superficial structures at the upper part of the back of the neck, the posterior jugular vein passes on to the sterno-cleido-mastoid, where it opens into the external jugular. The **middle occipital vein** (inconstant) accompanies the occipital artery, and usually opens into the internal jugular. The **internal occipital vein,** having in some cases pierced the trapezius, passes beneath the complexus, and enters the suboccipital triangle. In this situation it joins the suboccipital plexus, from which the deep cervical and vertebral veins emerge.

Occipital Glands.—These glands are usually two in number, and lie over the occipital portion of the trapezius, or over the upper part of the complexus. They receive their afferent lymphatics from the back part of the scalp, and their efferent lymphatics pass to the superficial cervical glands.

Deep Cervical Artery.—This vessel is a branch of the superior intercostal of the second part of the subclavian. Having passed backwards between the transverse process of the seventh cervical vertebra and the neck of the first rib, it ascends upon the semispinalis colli, under cover of the complexus, towards the level of the spine of the axis, where it anastomoses with the deep branch of the arteria princeps cervicis of the occipital. In its course it furnishes a *spinal branch*, which enters the spinal canal through the intervertebral foramen for the eighth cervical nerve, and *muscular branches*, which anastomose with branches of the vertebral artery.

The **deep cervical vein** commences, within the suboccipital triangle, in the suboccipital plexus, which receives the internal occipital

vein. It descends, in company with the deep cervical artery, to the lower part of the neck, where it passes forwards between the transverse process of the seventh cervical vertebra and the neck of the first rib, and ends by joining the vertebral vein just before that vessel terminates in the innominate vein.

In addition to the muscular branches of the occipital and deep cervical arteries, the deep muscles of the back of the neck receive twigs from the second part of the vertebral artery, which traverses the costo-transverse foramina of the upper six cervical vertebræ. These twigs pass backwards through the intertransverse spaces, and anastomose with branches of the arteria princeps cervicis and deep cervical arteries.

Suboccipital Region — Muscles — Rectus Capitis Posticus Major —*Origin.*—One of the tubercles in which the spine of the axis terminates.

Insertion.—The outer part of the inferior curved line of the occipital bone, and the subjacent area.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is upwards and outwards.

Action.—(1) To rotate the head towards the same side; and (2) to extend the head.

The muscle is triangular, and its insertion is slightly overlapped by the obliquus capitis superior.

Rectus Capitis Posticus Minor—*Origin.*—The posterior arch of the altas, close to, and encroaching upon, the posterior tubercle.

Insertion.—The inner third of the inferior curved line of the occipital bone, and the subjacent area as low as the foramen magnum.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is upwards in an expanded manner.

Action.—To extend the head.

The muscle is fan-shaped, and lies deeper than, and internal to, the rectus capitis posticus major.

Obliquus Capitis Inferior—*Origin.*—One of the tubercles in which the spine of the axis terminates.

Insertion.—The lower surface of the extremity of the transverse process of the atlas at its back part.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is outwards and slightly upwards.

Action.—To rotate the atlas, along with the head, towards the same side.

The muscle is thick and fleshy. At its origin it is interposed between the rectus capitis posticus major superiorly and the highest bundle of the semispinalis colli inferiorly. The great occipital nerve winds round its lower border.

Obliquus Capitis Superior—*Origin.*—The upper surface of the

extremity of the transverse process of the atlas at its back part.

Insertion.—The occipital bone between the outer parts of the superior and inferior curved lines.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is upwards and inwards.

Action.—(1) To extend the head ; and (2) to act as a slight lateral flexor of the head.

The muscle is triangular.

Suboccipital Triangle.—This triangle is situated under cover of the upper part of the complexus, close below the occipital bone.

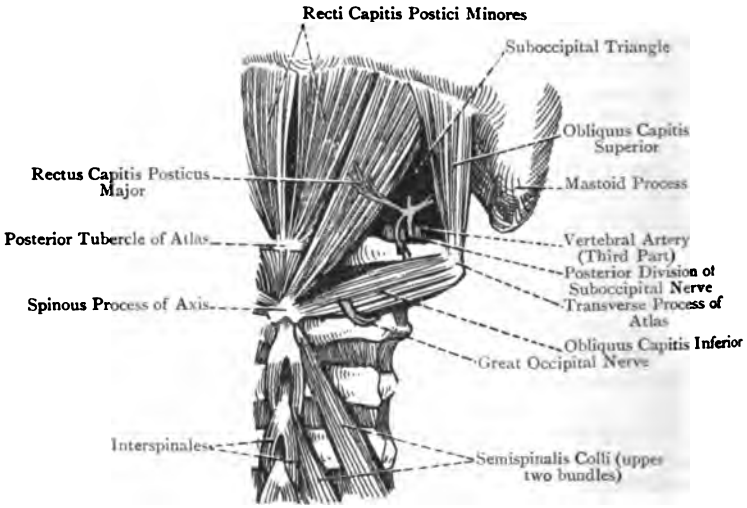


FIG. 419.—THE SUBOCCIPITAL TRIANGLE.

Boundaries—*Supero-internal.*—The rectus capitis posticus major. *Supero-external.*—The obliquus capitis superior. *Inferior.*—The obliquus capitis inferior. The **roof** is formed by the complexus, and the **floor** by half of the posterior arch of the atlas, and half of the posterior occipito-atlantal ligament. The **contents** are (1) the third part of the vertebral artery, (2) the suboccipital plexus of veins, and (3) the posterior primary division of the suboccipital nerve.

Third Part of the Vertebral Artery.—The vertebral artery, having emerged from the costo-transverse foramen of the atlas, enters upon the third part of its course, and takes a winding course backwards and inwards. It lies in the vertebrarterial groove of the atlas, the posterior primary division of the suboccipital nerve being beneath it, and it passes under an arched band of the

posterior occipito-atlantal ligament. It leaves the suboccipital triangle by piercing the dura mater, and enters the cranial cavity through the foramen magnum. The third part of the vessel furnishes *muscular branches* to the adjacent muscles which anastomose with the arteria princeps cervicis of the occipital, and the deep cervical of the superior intercostal.

Suboccipital Plexus of Veins.—This plexus is formed by branches which proceed from (1) the intraspinal venous plexus, (2) the adjacent muscles, and (3) the occipital periosteum. It receives the internal occipital vein, and the blood is conveyed away from it by the deep cervical vein, already described, and the vertebral vein, which will be afterwards considered.

Posterior Primary Division of the Suboccipital Nerve.—This division passes backwards, as a single nerve, in the vertebrarterial groove of the atlas, lying between the bone and the third part of the vertebral artery. On entering the suboccipital triangle it divides into branches which supply the obliqui, recti postici, and complexus muscles.

Posterior Primary Divisions of the Cervical Spinal Nerves.—The cervical nerves are eight in number, the first being known as the **suboccipital nerve.** Each breaks up into an anterior and a posterior primary division. The posterior primary division of the first or suboccipital is single, and has just been described. The posterior primary divisions of the lower seven arise in the intervertebral foramina, and each soon divides into an external and internal branch. The *external branches* of all are distributed to the deep muscles, and do not become cutaneous. The *internal branch* of the posterior primary division of the second, which is of large size, constitutes the **great occipital nerve.** It winds round the lower border of the obliquus capitis inferior, and pierces the complexus, to which it gives branches. Thereafter it may pierce the trapezius to reach its cutaneous distribution, which has been already described. The *internal branches* of the third, fourth, and fifth are directed inwards *upon* the semispinalis colli, to which, as well as to the complexus, they give branches. Close to the cervical spinous processes they pass backwards, internal to the biventer cervicis (part of the complexus), and, having pierced the trapezius, they reach the integument, which they supply. The internal branch of the posterior primary division of the third, before piercing the trapezius, gives off a small ascending branch, known as the **least** or **third occipital.** It passes upwards, lying at first under cover of the trapezius, and then passing through it, to reach the occipital integument. The *internal branches* of the posterior primary divisions of the sixth, seventh, and eighth are directed inwards towards the cervical spinous processes *beneath* the semispinalis colli, and are distributed to the adjacent muscles. They do not furnish any branches to the integument.

The Scalp and Temporal Region.

Scalp—Fascia.—The superficial fascia is firm and granular, and is separated into lobules by fibrous processes which pass between the skin and the epicranial aponeurosis. The deep fascia is represented by the epicranial aponeurosis of the occipito-frontalis muscle, to be presently described.

Nerves of the Scalp Proper.—The great, small, and least or third occipital nerves, and the mastoid branch of the great auricular have been already described. In the **fronto-parietal region** two sensory nerves are met with, namely, the supra-orbital and supra-trochlear, both of which are derived from the frontal nerve, which is one of the branches of the ophthalmic division of the fifth cranial nerve.

The **supra-orbital nerve,** which is of large size, leaves the orbit through the supra-orbital foramen. It then ascends, lying at first beneath the upper part of the orbicularis palpebrarum and the frontalis muscles, but subsequently piercing the latter muscle in two branches, outer and inner. The outer branch is the larger of the two, and its offsets extend well back over the parietal region. As the supra-orbital nerve passes through the supra-orbital foramen it furnishes one or two twigs to the mucous membrane of the frontal air-sinus and to the diploë of the frontal bone, and, after emerging from the foramen, it sends downwards palpebral branches to the integument of the upper eyelid. Thereafter the nerve supplies the integument of the fronto-parietal region.

The outer and inner branches of the supra-orbital nerve sometimes emerge from the orbit separately, the outer branch passing through the supra-orbital foramen, and the inner branch passing over the frontal notch

The **supratrochlear nerve,** which is of small size, is internal to the supra-orbital nerve. It leaves the orbit close to the internal angular process of the frontal bone, where it lies above the trochlea or pulley of the superior oblique muscle of the eyeball. It then ascends beneath the upper part of the orbicularis palpebrarum and the frontalis muscles, and, piercing the latter muscle, it has a limited distribution to the frontal integument close to the median line. As the nerve leaves the orbit it furnishes palpebral twigs to the inner part of the integument of the upper eyelid.

Arteries.—The third part of the occipital artery has been already described. The arteries of the **fronto-parietal region** are three in number, namely, the supra-orbital, frontal, and anterior branch of the superficial temporal.

The **supra-orbital artery** is a branch of the ophthalmic, and emerges from the orbit with the supra-orbital nerve. It is distributed to the structures covering the frontal bone, and anastomoses with the frontal, and the anterior division of the superficial temporal, arteries. In the supra-orbital foramen it furnishes one or two branches to the mucous membrane of the frontal air-sinus and to

the diploë of the bone, and, after emerging from the foramen, it sends downwards palpebral branches to the integument of the upper eyelid.

The **supra-orbital vein** passes downwards and inwards to a point just above the inner canthus, where it joins the frontal vein. In this manner the angular vein is formed, which is the commencement of the facial vein. The supra-orbital vein receives tributaries from the frontal region and the upper eyelid, and in the region of the inner canthus it communicates with the superior ophthalmic vein. It also communicates with the superior ophthalmic vein through the supra-orbital notch, and this communication receives the frontal diploic vein, which returns the blood from the diploë of the frontal bone and mucous membrane of the frontal air-sinus.

The **frontal artery,** like the supra-orbital, is a branch of the ophthalmic, and emerges from the orbit with the supratrochlear nerve. It is distributed to the structures over the frontal bone internal to the supra-orbital artery, with which it anastomoses, as well as with its fellow of the opposite side.

The **frontal vein,** of large size, passes downwards near the median line, and at a point just above the inner canthus is joined by the supra-orbital vein, the resultant vessel being the angular vein. At the root of the nose it communicates with its fellow of the opposite side by a transverse vessel, called the **transverse nasal vein.**

The supra-orbital and frontal veins communicate with each other, and with the tributaries of the anterior branch of the superficial temporal vein.

The anterior branch of the superficial temporal artery will be described in connection with the temporal region.

Occipito-frontalis.—This muscle consists of the following parts: (1) the occipitalis, (2) the frontalis, and (3) the epicranial aponeurosis.

Occipitalis.—This consists of two thin fleshy bellies, right and left. *Origin.*—(1) The outer parts of the highest and superior curved lines of the occipital bone; and (2) the outer surface of the mastoid process of the temporal bone, immediately above the insertion of the sterno-cleido-mastoid muscle.

Insertion.—The epicranial aponeurosis.

Each belly forms a thin, broad sheet, the length of the fasciculi being about 1½ inches. The two bellies, right and left, are separated towards the median line by a portion of the epicranial aponeurosis, which here dips down between them.

Frontalis.—This consists of two parts, right and left, which are separated superiorly by a narrow angular portion of the epicranial aponeurosis, but inferiorly, and for the most part, they are in contact. *Origin.*—(1) The subcutaneous tissue of the eyebrow and root of the nose, where the fibres blend with the upper part of the orbicularis palpebrarum and the corrugator supercilii; and (2) slightly from the external angular process of the frontal bone, and from the nasal bone.

Insertion.—The epicranial aponeurosis, a little below the level of the fronto-parietal suture.

The fasciculi are about 3½ inches long, and the innermost fibres inferiorly are regarded by some as being prolonged downwards upon the nasal bone as the pyramidalis nasi muscle.

Epicranial Aponeurosis.—This is the intermediate tendon of the occipito-frontalis muscle. It forms an aponeurotic stratum beneath the superficial fascia, and is connected to the skin by fibrous processes, which separate the superficial fascia into lobules. Its deep surface is loosely connected by areolar tissue to the subjacent

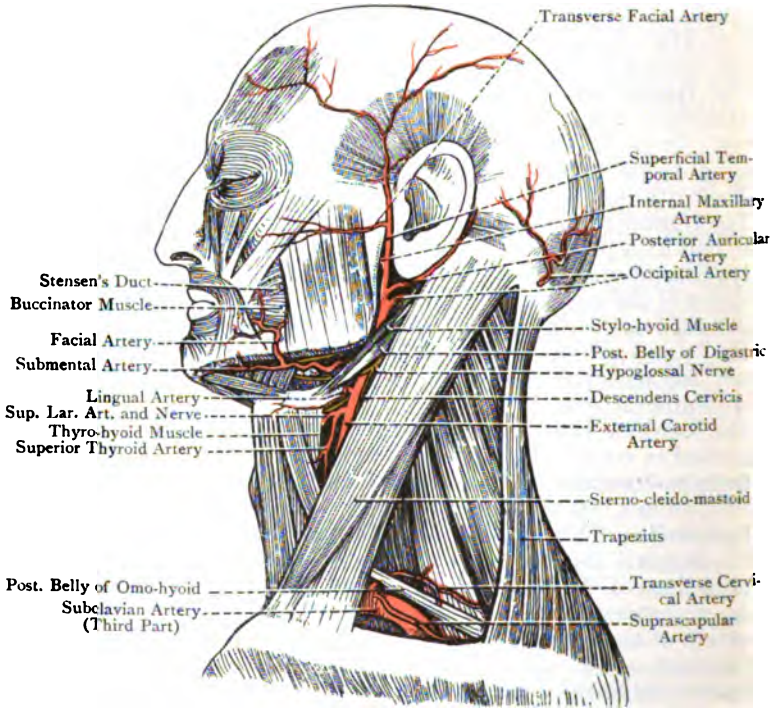


FIG. 420.—THE LEFT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed).

periosteum. Posteriorly it gives insertion to the two bellies of the occipitalis muscle, and, in the interval between these, it dips down to be attached to the inner part of the highest curved line of the occipital bone and the external occipital protuberance. Anteriorly it gives insertion to the two halves of the frontalis muscle. Laterally, below the superior temporal ridge, it is prolonged downwards over the temporal fascia as a delicate expansion, which gives origin to the attollens auriculam and attrahens auriculam muscles.

Nerve-supply.—The occipitalis muscle is supplied by the pos-

terior auricular branch of the facial nerve, and the frontalis muscle is supplied by the temporal branches of the temporo-facial division of the facial nerve.

Action.—The two bellies of the occipitalis draw backwards the epicranial aponeurosis, and along with it the scalp. The two halves of the frontalis, acting from below, draw forwards the epi cranial aponeurosis, and along with it the scalp. Acting from above they elevate the eyebrows, and throw the skin of the frontal region into transverse wrinkles. When the occipitalis and frontalis act simultaneously the scalp is drawn backwards, and the eyebrows are forcibly raised. When the two muscles act alternately the scalp is drawn backwards and forwards.

Pericranium.—This is the periosteum of the cranium, and it is loosely connected by areolar tissue to the superjacent epicranial aponeurosis.

Temporal Region—Nerves.—These are as follows: (1) the temporal branches of the temporo-facial division of the facial nerve; (2) the auriculo-temporal nerve; and (3) the temporal branch of the orbital or temporo-malar nerve.

The **temporal branches of the temporo-facial division of the facial nerve** pass upwards a little in front of the auricle, and supply the following muscles: the frontalis, upper part of the orbicularis palpebrarum, corrugator supercilii, attollens auriculam, and attrahens auriculam. They communicate with the auriculo-temporal, temporal branch of the orbital, and supra-orbital nerves.

The **auriculo-temporal nerve** is a branch of the posterior division of the inferior maxillary nerve, which is the third division of the fifth cranial nerve. It emerges from the upper part of the parotid gland, and ascends immediately in front of the auricle, in company with the superficial temporal artery, lying between that vessel and the auricle.

Branches.—In this part of its course the nerve furnishes the following branches: (1) two *meatal branches* to the meatus auditorius externus, which enter the canal between its osseous and cartilaginous walls, and supply the integument of the meatus, the upper of the two branches giving an offset to the membrana tympani; (2) two *anterior auricular branches*, which supply the skin of the tragus and outer aspect of the auricle over its upper half; and (3) *temporal branches*, which supply the integument above and in front of the auricle, and of the temporal region generally.

The **temporal branch of the orbital or temporo-malar nerve** from the superior maxillary is of small size, and pierces the temporal fascia about 1 inch above the anterior part of the zygoma, and close behind the marginal process of the malar bone. Having communicated with one of the temporal branches of the facial nerve, it has a limited distribution to the integument of the anterior part of the temporal region.

The **superficial temporal artery** is one of the terminal branches of the external carotid artery, from which it arises within the parotid

gland on a level with the neck of the lower jaw. Emerging from the gland it ascends in front of the auricle, in company with the auriculo-temporal nerve, which lies between the vessel and the auricle, and, after a course of about 2 inches, it divides into its two terminal branches.

Branches. — These are as follows: (1) transverse facial; (2) articular; (3) anterior auricular; (4) middle temporal; (5) orbital; and (6) terminal, namely, anterior temporal and posterior temporal.

The **transverse facial branch** will be described in connection with the face. It arises within the parotid gland, and in its course

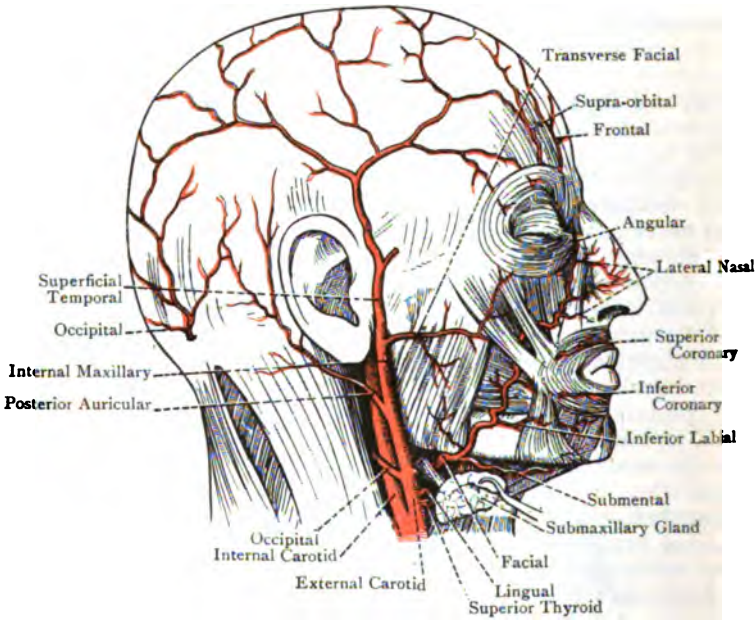


FIG. 421.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

furnishes glandular branches. The **articular branches** supply the temporo-mandibular joint. The **anterior auricular branches** supply the outer aspect of the auricle, and in part the meatus auditorius externus. The **middle temporal branch** pierces the temporal fascia and temporal muscle immediately above the zygoma, and then ascends in a groove on the outer surface of the squamous part of the temporal bone. It gives branches to the temporal muscle, and anastomoses with the deep temporal arteries, which are branches of the internal maxillary. The **orbital branch** passes forwards close above the zygoma, where it lies between the two layers of the temporal fascia. It is distributed to the outer part of the orbi-

cularis palpebrarum muscle. The **anterior temporal branch** passes forwards and upwards in a tortuous manner, and is distributed to the structures covering the frontal bone, where it anastomoses with the supra-orbital and frontal branches of the ophthalmic artery, and with its fellow of the opposite side. The **posterior temporal branch** takes an arched course upwards and backwards above the auricle, supplying the adjacent structures, and anastomosing with the posterior auricular and occipital arteries, and with its fellow of the opposite side.

The **superficial temporal vein** is formed in front of the auricle by the union of an anterior and a posterior branch, the former communicating freely with the supra-orbital and frontal veins, and the latter with the posterior auricular vein and the occipital venous plexus. Above the zygoma it is joined by the middle temporal vein, which originates in a plexus in the temporal fossa, and pierces the temporal muscle and temporal fascia, receiving in its course the orbital vein. The superficial temporal vein then descends over the zygoma and enters the parotid gland, within which it receives the anterior auricular, articular, and transverse facial veins. Finally, it joins the internal maxillary vein about the level of the neck of the lower jaw to form the temporo-maxillary vein.

Extrinsic Muscles of the Auricle.—These are three in number, as follows: (1) attollens auriculam; (2) attrahens auriculam; and (3) retrahens auriculam.

Attollens Auriculam—*Origin.*—The lateral part of the epicranial aponeurosis.

Insertion.—The inner or cranial surface of the auricle over the convexity corresponding to the fossa of the antihelix on its outer surface.

Nerve-supply.—The temporal portion of the temporo-facial division of the facial nerve. The posterior part of the muscle may be supplied by the posterior auricular branch of the facial nerve.

The muscle is very thin, pale, and fan-shaped, and its fibres converge in a downward direction.

Action.—To raise the auricle.

Attrahens Auriculam — *Origin.*—The lateral part of the epicranial aponeurosis in front of the attollens auriculam, with which muscle it is continuous.

Insertion.—The anterior part of the helix of the auricle.

Nerve-supply.—The temporal portion of the temporo-facial division of the facial nerve.

The muscle is directed backwards.

Action.—To draw forwards the auricle.

Retrahens Auriculam—*Origin.*—The upper part of the outer surface of the mastoid process of the temporal bone.

Insertion.—The inner or cranial surface of the auricle over the convexity of the concha.

Nerve-supply.—The posterior auricular branch of the facial nerve.

The muscle is directed forwards.

Action.—To draw back the auricle.

The retrahens auriculam is more distinct than the other two muscles, and is usually arranged in two bundles.

Posterior Auricular Nerve.—This is a branch of the facial nerve immediately after it emerges from the aqueduct of Fallopius through the stylo-mastoid foramen. It passes upwards between the mastoid process and the auricle, where it lies deeply in company with the posterior auricular artery, and it divides into two branches—auricular and occipital. The *auricular branch* supplies the retrahens auriculam muscle on its deep aspect, and those intrinsic muscles of the auricle which lie on its inner or cranial aspect. It may also send a branch upwards beneath the retrahens auriculam to supply the posterior part of the attollens auriculam. The *occipital branch* passes backwards, and supplies the corresponding half of the occipitalis muscle. The posterior auricular nerve communicates with the small occipital and great auricular nerves, and also with the auricular branch (Arnold's nerve) of the pneumogastric.

Nerve of Arnold.—This is the auricular branch of the ganglion of the root of the pneumogastric nerve. Having traversed the auricular canaliculus in the petrous part of the temporal bone, it emerges through the auricular or tympano-mastoid fissure, between the mastoid process and tympanic plate, and thereafter divides into two branches—auricular and communicating. The *auricular branch* takes part in the supply of the inner or cranial surface of the auricle, and also supplies the lower and back part of the meatus auditorius externus ; and the *communicating branch* joins the posterior auricular nerve.

Posterior Auricular Artery.—This vessel is one of the two posterior branches of the external carotid artery, the other branch being the occipital artery. Having passed backwards and upwards under cover of the parotid gland, it lies deeply between the mastoid process and the auricle, in close relation to the posterior auricular nerve, and divides into two branches—auricular and mastoid. The *auricular branch* supplies the inner or cranial surface of the auricle and adjacent structures, and it anastomoses with the posterior branch of the superficial temporal artery. The *mastoid branch* passes backwards to the corresponding half of the occipitalis muscle, and anastomoses with the occipital artery.

The **posterior auricular vein** is of fairly large size, and returns the blood from the lateral portion of the scalp posteriorly, and the inner surface of the auricle. Its radicles communicate with the occipital plexus and with the posterior branch of the superficial temporal vein. The vessel passes downwards and forwards over the upper part of the sterno-cleido-mastoid muscle, and terminates about the level of the angle of the lower jaw by joining the posterior division of the temporo-maxillary vein to form the external jugular vein.

Posterior Auricular, or Mastoid, Glands.—These glands lie close

to the insertion of the sterno-cleido-mastoid muscle. They receive their afferent lymphatics from the lateral part of the back of the scalp and the back of the auricle, and their efferent lymphatics pass to the superficial cervical glands.

Temporal Fascia.—This is a strong aponeurosis which covers the temporal muscle. Superiorly it is attached from before backwards to the temporal border of the malar bone, the superior temporal ridge of the frontal and parietal bones, and the supramastoid crest of the temporal bone. Inferiorly it divides into two laminæ, which are attached to the outer and inner margins of the upper border of the zygomatic arch. Between these two laminæ there are a small amount of adipose tissue and the orbital branch of the superficial temporal artery. Superficial to the fascia there are the delicate prolongation of the lateral portion of the epicranial aponeurosis and the attollens and attrahens auriculam muscles. Superiorly the fascia gives origin, by its deep surface, to the superficial fibres of the temporal muscle, but it is separated from that muscle towards the zygoma by adipose tissue.

Temporal Muscle — *Origin.*—(1) The temporal fossa, extending as high as the inferior temporal ridge of the frontal and parietal bones, and as low as the infratemporal crest on the external surface of the great wing of the sphenoid ; and (2) the deep surface of the temporal fascia over its upper part.

The muscle is fan-shaped. The anterior fasciculi descend almost vertically ; the posterior fasciculi pass almost horizontally forwards ; and the intervening fasciculi descend with varying degrees of obliquity.

A complete description of the temporal muscle will be found on p. 1122.

The Cranial Cavity.

The meninges of the encephalon, namely (1) the dura mater, with its septa and venous sinuses, (2) the arachnoid membrane, and (3) the pia mater, will be found described on p. 1355, *et seq.*

Cranial Nerves at the Base of the Skull.—The cranial nerves are arranged in twelve pairs, and as they leave the cranial cavity they receive sheaths from the meninges of the encephalon.

The **olfactory nerves,** which are connected with the under aspect of the olfactory bulb, pass through the foramina in one half of the cribriform plate of the ethmoid bone, and so reach the upper or olfactory region of the nasal fossa.

The **nasal nerve,** after emerging from the anterior ethmoidal foramen or canal, passes obliquely forwards and inwards on the cribriform plate of the ethmoid bone to the nasal slit, which lies by the side of the fore part of the crista galli. It then leaves the anterior fossa through this slit, and so reaches the groove on the posterior surface of the nasal bone. The nerve is situated beneath the dura mater of the anterior fossa.

The **third** or **oculo-motor nerve** pierces the dura mater, which

forms the outer wall of the cavernous sinus, a little in front of the posterior clinoid process of the sphenoid bone.

The **fourth** or **trochlear nerve,** of small size, pierces the dura mater at a point a little behind the posterior clinoid process of the sphenoid bone, external to the third nerve, and beneath the free margin of

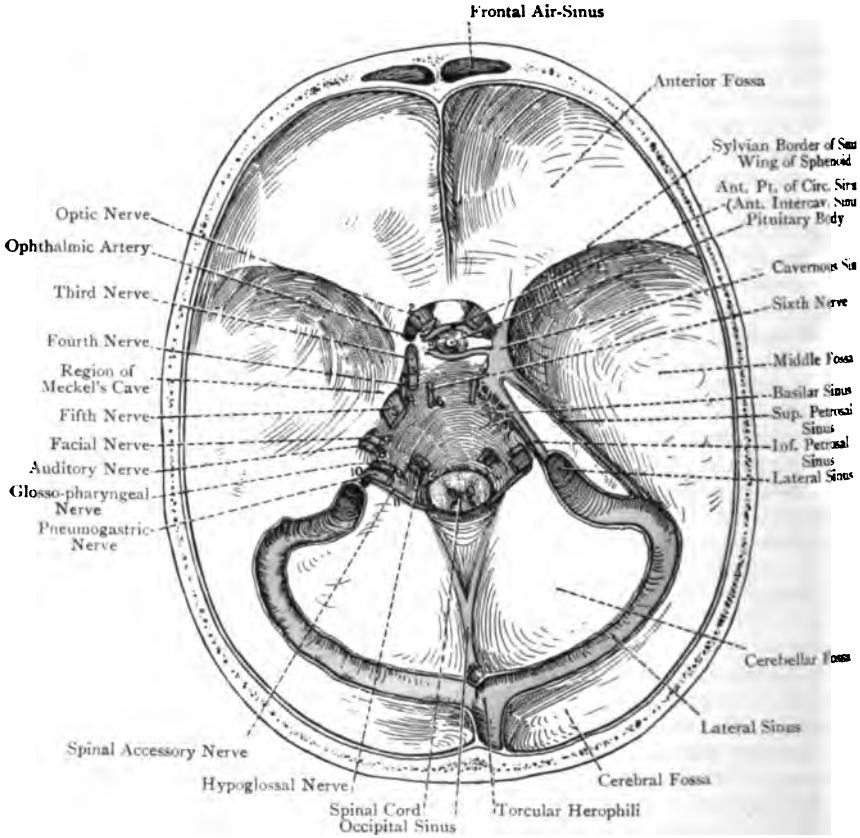


FIG. 422.—THE INTERNAL BASE OF THE SKULL, SHOWING THE CRANIAL NERVES AND VENOUS SINUSES.

the tentorium cerebelli. Thereafter it traverses the outer wall of the cavernous sinus.

The **fifth** or **trigeminal nerve** consists of two roots—sensory and motor. These two roots pierce the dura mater at the apex of the petrous part of the temporal bone, and enter a recess of the dura mater, called *Meckel's cave*, where they will be presently described.

The **sixth** or **abducent nerve** pierces the dura mater at the outer border of the dorsum sellæ of the sphenoid bone, a little below the

posterior clinoid process, where it occupies a notch on the bone. It lies a little to the inner side of the fifth nerve.

The **seventh** or **facial nerve,** the **eighth** or **auditory nerve,** and the **pars intermedia of Wrisberg,** accompanied by the internal auditory artery, enter the meatus auditorius internus.

The **ninth** or **glosso-pharyngeal nerve,** the **tenth** or **pneumogastric nerve,** and the **eleventh** or **spinal accessory nerve** pass through the middle compartment of the jugular foramen. This foramen is divided into three compartments, namely, antero-internal, middle, and postero-external. The *antero-internal compartment* gives passage to the inferior petrosal sinus. The *middle compartment* transmits the glosso-pharyngeal, pneumogastric, and spinal accessory nerves, in this order from before backwards. The glosso-pharyngeal nerve pierces the dura mater separately, and receives special sheaths from the dura mater and arachnoid membrane. The pneumogastric and spinal accessory nerves pass through the same aperture in the dura mater, and receive common sheaths from the dura and arachnoid membrane. The *postero-external compartment* transmits the lateral sinus, which terminates in the internal jugular vein.

The **twelfth** or **hypoglossal nerve** pierces the dura mater in two bundles, which pass through separate apertures. As these bundles pass through the anterior condylar foramen they unite to form one nerve.

Structures passing through the Foramen Magnum.—(1) The medulla oblongata, with its membranes, passes out and becomes the spinal cord. (2) The *spinal portion* of the spinal accessory nerve, of either side, having ascended from the interval between the posterior roots of the cervical spinal nerves and the ligamentum denticulatum, enters the cranial cavity. It then turns outwards to the middle compartment of the jugular foramen, where it meets the *bulbar portion* of the nerve, with which it becomes closely connected as it passes through the foramen. (3) The vertebral artery of each side enters the cranial cavity, after having left the vertebrarterial groove on the upper aspect of the posterior arch of the atlas. (4) The two anterior spinal branches of the vertebral arteries descend on the front of the medulla oblongata, and, inclining inwards towards each other, they unite in passing through the foramen magnum to form the anterior spinal artery. (5) The two posterior spinal branches of the vertebral arteries pass outwards through the foramen magnum.

Gasserian Ganglion.—The Gasserian ganglion occupies the Gasserian depression on the superior surface of the petrous part of the temporal bone near the apex, where it lies in a recess of the dura mater, called *Meckel's cave.* It is somewhat semilunar, being convex in front and concave behind, and measures fully ½ inch from before backwards. It is associated with the sensory root of the fifth nerve, which, before entering the posterior concave aspect of the ganglion, becomes expanded, its fasciculi at the same

time becoming separated and assuming a plexiform arrangement. Internally the ganglion is intimately related to the back part of the cavernous sinus and the internal carotid artery at the foramen lacerum medium, and on this aspect it receives delicate filaments from the carotid sympathetic plexus. The motor root of the fifth nerve, small in size, lies in close contact with the deep surface of the ganglion; but there is no blending of the two sets of fibres, the motor root passing independently in an outward direction to the foramen ovale. The great superficial petrosal nerve, on its way to the foramen lacerum medium, passes beneath the ganglion.

The ganglion contains cells similar to those of a spinal ganglion, and it receives its blood from the middle and small meningeal arteries.

Branches.—The branches of the ganglion arise from its anterior convex aspect, and are known as *divisions*. They are as follows: the first or ophthalmic division; the second or superior maxillary division; and the third or inferior maxillary division. The ophthalmic and superior maxillary nerves are entirely sensory, but the inferior maxillary nerve, being joined by the motor root, is both sensory and motor.

The **first division of the fifth nerve,** or the **ophthalmic nerve,** is the smallest of the three branches of the ganglion. It passes forwards in the outer wall of the cavernous sinus, where it lies below the fourth nerve. On approaching the sphenoidal fissure it parts with its chief branches, in the following order from behind forwards: (1) **nasal**, (2) **lachrymal**, and (3) **frontal,** the last-named representing the continuation of the nerve. All these three branches enter the orbit through the sphenoidal fissure. As the ophthalmic nerve passes forwards it receives a communicating branch from the cavernous sympathetic plexus, and it furnishes a *recurrent meningeal branch* to the tentorium cerebelli. It also communicates with each of the third, fourth, and sixth nerves.

The **second division of the fifth,** or the **superior maxillary nerve,** passes horizontally forwards for a short distance in the lower part of the outer wall of the cavernous sinus, and it leaves the cranial cavity through the foramen rotundum, which leads to the sphenomaxillary fossa. Before leaving the cranial cavity it furnishes a delicate *recurrent meningeal branch* to the dura mater of the middle fossa.

The **third division of the fifth,** or the **inferior maxillary nerve,** is the largest of the three branches of the ganglion. It passes downwards to the foramen ovale, through which it leaves the cranial cavity, and so enters the zygomatic fossa. It is accompanied by the motor root of the fifth nerve, which joins it as it passes through the foramen ovale. The *recurrent meningeal branch* of the inferior maxillary nerve is not given off until after the parent trunk has issued through the foramen ovale, and it enters the cranial cavity through the foramen spinosum, in company with the middle meningeal artery. It then divides into two offsets, one of which supplies the dura mater over the great wing of the sphenoid bone.

and the other passes through the fissure between petrous and squamous parts of the temporal bone to supply the mucous membrane of the mastoid cells.

Great Superficial Petrosal Nerve.—This nerve is a branch of the geniculate ganglion of the facial nerve in the aqueduct of Fallopius. It enters the middle fossa of the base of the skull through the hiatus Fallopii, and passes forwards and inwards in a groove on the superior surface of the petrous part of the temporal bone. Having passed beneath the Gasserian ganglion, it enters the upper part of the foramen lacerum medium, where it is placed on the outer side of the internal carotid artery, and it joins the great deep petrosal nerve from the carotid sympathetic plexus. In this manner the Vidian nerve is formed, which enters the pterygoid or Vidian canal by its opening on the anterior aspect of the foramen lacerum medium, and so reaches Meckel's ganglion in the spheno-maxillary fossa. The great superficial petrosal nerve is accompanied by the petrosal branch of the middle meningeal artery.

Small Superficial Petrosal Nerve.—This nerve represents the continuation, through the tympanic plexus, of the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal nerve. It is reinforced by a small branch from the geniculate ganglion of the facial nerve, which joins it as it traverses a small canal in the petrous part of the temporal bone, beneath the canal for the tensor tympani muscle. The nerve enters the middle fossa through the accessory hiatus on the superior surface of the *pars petrosa*. It then passes for a little forwards and inwards, and leaves the cranial cavity through the canaliculus innominatus (when present), or through the fissure between the pars petrosa and the great wing of the sphenoid, or, it may be, through the foramen ovale, after which it terminates in the otic ganglion.

External Superficial Petrosal Nerve.—This nerve, which is inconstant, passes from the sympathetic plexus on the middle meningeal artery backwards and outwards on the superior surface of the petrous part of the temporal bone, and it leaves the cranial cavity through a minute aperture situated within the thin margin of the hiatus Fallopii. It terminates in the geniculate ganglion of the facial nerve.

Interior of the Cavernous Sinus.—The interior of this sinus is broken up by a number of delicate trabeculæ, which are arranged in a reticular manner. The outer wall of the sinus contains the following cranial nerves, in order from above downwards: the third, the fourth, the ophthalmic division of the fifth, and the superior maxillary division of the fifth. These nerves, as they pass forwards, are separated from the blood-current by the endothelial lining of the outer wall of the sinus. The cavity of the sinus is traversed by (1) the cavernous part of the internal carotid artery, accompanied by the cavernous sympathetic plexus, and (2) the sixth cranial nerve, which lies in close contact with the outer side of the internal carotid artery. These structures are also separated from the blood-current by the endothelial lining of the sinus.

For the processes and other sinuses of the dura mater see p. 1358, *et seq.*

Cavernous Part of the Internal Carotid Artery.—This part of the internal carotid artery lies within the cavernous sinus, which occupies the cavernous groove on the lateral aspect of the body of the sphenoid bone. It is separated from the blood-current by the endothelial lining of the sinus. The course of the vessel is at first upwards, between the lingula sphenoidalis and the posterior petrosal

process of the sphenoid ; then forwards, as far as the anterior clinoid process of the sphenoid ; and, finally, upwards internal to the anterior clinoid process. In the latter situation it pierces the dura mater which forms the roof of the cavernous sinus, and enters upon the cerebral part of its course.

The vessel is accompanied by the cavernous sympathetic plexus, and the sixth cranial nerve lies in close contact with its outer side, all being invested by the endothelial lining of the sinus.

Branches.—These are as follows : *pituitary*, to the pituitary body ; *ganglionic* to the Gasserian ganglion ; *cavernous*, to the wall of the cavernous sinus, and to the third, fourth, fifth, and sixth cranial nerves ; *meningeal*, to the dura mater of the middle cranial fossa ; and the *ophthalmic artery*. The latter vessel arises from the cavernous part of the internal carotid on the inner side of the anterior clinoid process, and it enters the orbit, with the optic

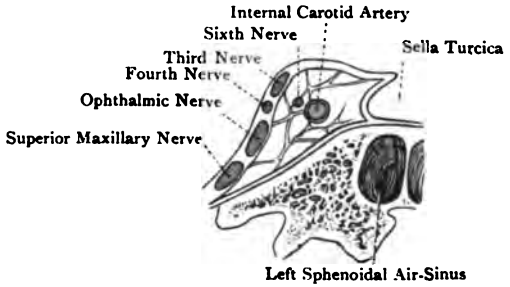


FIG. 423.—DIAGRAM OF THE LEFT CAVERNOUS VENOUS SINUS AND ITS OUTER WALL, SHOWING THE RELATIVE POSITIONS OF THE CONTAINED STRUCTURES (POSTERIOR VIEW).

nerve, through the optic foramen, lying at first beneath the nerve, and then on its outer side.

Cavernous Sympathetic Plexus.—This plexus is situated principally on the inner and lower aspects of the bend which the cavernous part of the internal carotid artery describes internal to the anterior clinoid process. Its branches are as follows : (1) *vascular*, to the internal carotid artery and its branches ; (2) *pituitary*, to the pituitary body ; (3) *communicating*, to the third, fourth, ophthalmic division of the fifth, and sixth cranial nerves ; and (4) the *sympathetic root* of the ciliary ganglion. The last-named branch enters the orbit through the sphenoidal fissure.

The **pituitary body** (*hypophysis cerebri*) is a small oval mass which is situated in the pituitary fossa, or sella turcica, of the sphenoid bone. It lies under cover of a circular fold of the dura mater, called the *diaphragma sellæ*, in the centre of which is an opening for the passage of the infundibulum. Its long measurement extends transversely, and it consists of two lobes—anterior or buccal, and posterior or cerebral. The anterior lobe is the larger of the two, and the posterior

lobe is connected with the anterior part of the tuber cinereum by means of the infundibulum.

The **infundibulum** projects downwards from the anterior part of the tuber cinereum to the posterior lobe of the pituitary body. Its upper part is hollow, and contains a funnel-shaped diverticulum of the cavity of the third ventricle.

Structure.—The **anterior lobe** consists of several tubules, lined with epithelium, and invested by capillary bloodvessels. The **posterior lobe,** though developed from the brain, is destitute of nervous elements. It is composed of a reticulum of connective tissue, which contains branched cells.

Development.—The **anterior lobe** is developed from a diverticulum of the buccal or stomatodæal epiblast, which is known as the **pouch of Rathke.** The diverticulum grows upwards, and, when the cranio-pharyngeal canal of early life becomes closed, the connection of the diverticulum with the buccal epiblast is severed. The diverticulum thereafter becomes converted into tubules, which form the anterior lobe. The **posterior lobe** of the pituitary body and the infundibulum, which is connected with it, are developed as a diverticulum which grows downwards from that part of the thalamencephalon or diencephalon which forms the floor of the third ventricle. The cavity of the diverticulum remains permanent in the upper part of its infundibular portion, but elsewhere it becomes obliterated. The lower part of the diverticulum thereafter becomes converted into a reticulum of connective tissue, with branched cells, which forms the posterior lobe.

Side of the Neck.

The side of the neck has a quadrilateral outline, the boundaries of which are as follows : *superior*, one half of the base of the inferior maxilla, and a line prolonged from the angle of that bone over the mastoid process to the inner third of the superior curved line of the occipital bone; *inferior*, the clavicle, and one half of the upper border of the manubrium sterni; *anterior*, the middle line of the neck, that is to say, a line connecting the symphysis of the inferior maxilla with the centre of the upper border of the manubrium sterni; and *posterior*, a line connecting the inner third of the superior curved line of the occipital bone with the outer third of the clavicle.

Landmarks.—The base and angle of the inferior maxilla can easily be felt, and the clavicle, together with the upper border of the manubrium sterni, is conspicuous. A deep depression, called the suprasternal or jugular fossa, is perceptible above the upper border of the manubrium sterni, lying between the sternal heads of origin of the sterno-cleido-mastoid muscles. The outline of the sterno-cleido-mastoid muscle is readily discernible when the head is turned so as to direct the face towards the opposite shoulder. The muscle extends in a diagonal direction from the sterno-clavicular joint to the mastoid process and outer half or two-thirds of the superior curved line of the occipital bone, and it divides the side of the neck into two triangles — anterior and posterior. A small triangular interval may be felt between the sternal and clavicular heads of origin of the sterno-cleido-mastoid, just above the inner end of the clavicle, in which the common carotid artery and internal jugular vein lie deeply. The external

jugular vein crosses the sterno-cleido-mastoid muscle in the direction of a line extending from a point just behind the angle of the inferior maxilla to a point above the centre of the clavicle, and it is accompanied by the superficial cervical glands. The common carotid artery lies under cover of the anterior border of the sterno-cleido-mastoid muscle, in the direction of a line drawn from the sterno-clavicular joint to a point midway between the angle of the inferior maxilla and the tip of the mastoid process of the temporal bone. The vessel extends along this line as high as the level of the upper border of the thyroid cartilage, and thereafter it is replaced by the external carotid artery. The internal jugular vein is close to the outer side of the common carotid artery, and the pneumogastric nerve lies deeply between the two vessels. If deep pressure is made over the common carotid artery, on a level with the cricoid cartilage of the larynx, the tubercle of the costal process of the sixth cervical vertebra (commonly spoken of as the anterior tubercle of the transverse process) may be felt. It is known as the *carotid tubercle of Chassaignac.*

The commencement of the right innominate vein and the bifurcation of the innominate artery lie behind the upper border of the right sterno-clavicular joint; and the commencement of the left innominate vein and the left common carotid artery lie behind the left sterno-clavicular joint. Near the middle line of the neck the anterior jugular vein descends vertically. The spinal portion of the spinal accessory nerve passes downwards and outwards beneath the anterior border of the sterno-cleido-mastoid to pierce the deep part of that muscle at about the junction of the upper fourth and lower three-fourths. The nerve is met with fully 1 inch below the tip of the mastoid process, and in the direction of a line let fall vertically from the mastoid tip. It is very nearly on a level with the body of the hyoid bone. Along the posterior border of the sterno-cleido-mastoid the lymphatic glands, known as the glandulæ concatenatæ, may be felt.

Important structures occupy the middle line of the neck, and can be usually distinguished without difficulty. These are as follows, in order from above downwards: (1) the body of the hyoid bone, lying just below the inferior maxilla, and having the great cornu projecting backwards and upwards on either side: (2) the thyro-hyoid membrane; (3) the thyroid cartilage, with its prominent angle or isthmus (pomum Adami) in the middle line, leading up to the V-shaped thyroid notch on the upper border, and its expanded ala on either side, each of which terminates posteriorly in a superior and an inferior cornu; (4) the crico-thyroid membrane: (5) the narrow, anterior part of the cricoid cartilage, which coincides with the level at which the anterior belly of the omo-hyoid muscle crosses the carotid sheath; and (6) the rings of the trachea, which, however, are covered superiorly by the isthmus of the thyroid body, and inferiorly by the sterno-hyoid and sterno-thyroid muscles and adipose tissue.

The lateral lobes of the thyroid body may be felt on either side of the larynx and trachea as low as about the fifth ring ; and, in young children, the thymus body extends upwards upon the trachea for some distance above the manubrium sterni.

The great cornu of the hyoid bone is the guide to the lingual artery for operative purposes, the vessel lying just above the great cornu.

The upper border of the thyroid cartilage is on a level with the disc between the bodies of the third and fourth cervical vertebræ.

The narrow anterior part of the cricoid cartilage is on a level with the disc between the bodies of the fifth and sixth cervical vertebræ, at which level the pharynx terminates in the œsophagus. In this situation a foreign body, when swallowed, is liable to become impacted.

Above the middle third of the clavicle, between the sterno-cleido-mastoid and trapezius muscles, there is a depression known as the supraclavicular fossa, which indicates the position of the subclavian or supraclavicular triangle, with the third part of the subclavian artery and the trunks of the brachial plexus of nerves.

Platysma Myoides—*Origin.*—The superficial fascia which covers the clavicular parts of the pectoralis major and deltoid muscles.

Insertion.—(1) The outer aspect of the base of the inferior maxilla from the symphysis to the anterior border of the masseter muscle ; and (2) the angle of the mouth, where the fibres blend with those of the depressor anguli oris and orbicularis oris.

Nerve-supply.—The inframandibular (cervical) branch of the cervico-facial division of the facial nerve, which communicates with branches of the superficial cervical nerve.

The fibres are directed upwards and forwards or inwards over the clavicle and side of the neck.

Action.—(1) To draw the angle of the mouth downwards and outwards ; (2) to act as a feeble depressor of the inferior maxilla ; (3) to raise the skin of the neck and upper pectoral region, as far out as the acromion process, throwing it into obliquely-disposed folds. By diminishing pressure upon the external jugular vein during forced inspiration the muscle contributes to the return of blood through that vessel.

The muscle forms an extensive, thin, pale sheet, which is embedded within the superficial fascia. In the region of the symphysis of the inferior maxilla the innermost fibres decussate across the middle line with those of the opposite side, the fibres of the right muscle being superficial. The muscle covers the external and anterior jugular veins, the superficial branches of the cervical plexus of nerves, the subclavian triangle, and the sterno-cleido mastoid, sterno-hyoid, omo-hyoid, and digastric muscles.

The platysma myoides in man is a remnant of a subcutaneous muscular sheet, called the *panniculus carnosus*, which exists in many animals, and by which the twitching of the skin is produced.

Jugular Veins.—The jugular veins are four in number on either side, namely, anterior, external, posterior, and internal.

The **anterior jugular vein** commences in the roof of the submaxillary or digastric triangle, where it is formed by the union of radicles which communicate with the submental vein, and are joined by radicles which have descended from the structures over the body of the inferior maxilla. It descends vertically near the median line, lying at first superficial to the deep cervical fascia, but sub-

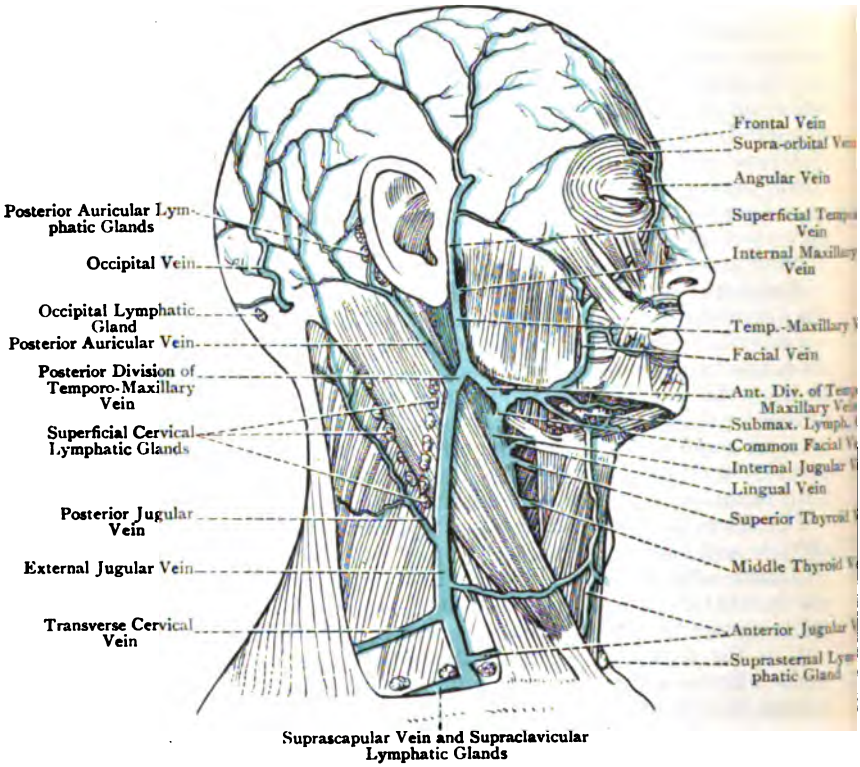


FIG. 424.—THE SUPERFICIAL VEINS AND SUPERFICIAL LYMPHATIC GLANDS OF THE RIGHT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides Muscle has been removed).

sequently entering the suprasternal interfascial space, or space of Burns. It then describes a bend, and, passing outwards behind the sterno-cleido-mastoid muscle, and in front of the scalenus anticus, it opens into the lower part of the external jugular vein. It may, however, open into the subclavian vein. It communicates with the external jugular vein by one or more branches, and it usually receives a branch from the facial vein which descends along the anterior

border of the sterno-cleido-mastoid and joins it towards the lower part of the neck. Further, it communicates with its fellow of the opposite side by a transverse branch which crosses in front of the trachea, and lies in Burns's space.

The anterior jugular veins are usually asymmetrical, one or other being of small size. Occasionally there is only one vein, which is mesially placed, and, under these circumstances, it divides into two vessels inferiorly. The anterior jugular vein is destitute of valves.

The **external jugular vein** commences close behind the angle of the inferior maxilla in the substance of the parotid gland, where it is formed by the union between the posterior division of the temporo-maxillary vein and the posterior auricular vein. Having emerged from the parotid gland it descends almost vertically to a point above the centre of the clavicle. In its course the vessel crosses the sterno-cleido-mastoid muscle, lying superficial to its sheath, and beneath the superficial fascia containing the fibres of the platysma myoides. At this level the main part of the superficial cervical nerve courses forwards beneath the vein, and offsets of the nerve pass over it. Having crossed the sterno-cleido-mastoid muscle, the vein descends not far from its posterior border, where it lies in the roof of the subclavian or supraclavicular triangle, over the third part of the subclavian artery. Up to this point the vessel is superficial to the deep cervical fascia, but it now pierces that fascia and opens into the subclavian vein.

The course of the external jugular vein is indicated by a line drawn from a point close behind the angle of the inferior maxilla to a point above the centre of the clavicle. Its tributaries are as follows: (1) posterior jugular, which joins it about the middle of the neck; (2) transverse cervical; (3) suprascapular; and (4) anterior jugular, the latter three joining it not far from its termination. It also communicates with the anterior jugular vein by one or more branches. The vessel is provided with valves, both at its termination and about 1½ inches above this point, and the transverse cervical and suprascapular veins are also furnished with valves, where they open into the external jugular vein, or near their orifices.

The external jugular vein is sometimes very small, or even absent; and it may communicate with the cephalic vein by a vessel which passes over the clavicle.

Development.—The external jugular vein is usually regarded as being developed from the primitive jugular vein; but according to some authorities the primitive jugular vein gives rise to the internal jugular vein, the external jugular being of later development.

The **posterior jugular vein** represents the most external occipital vein, and is formed by tributaries which issue from the outer part of the occipital plexus, reinforced by veins from the superficial structures at the back of the neck. Having usually received the mastoid emissary vein, it passes downwards and forwards, and joins the external jugular vein about the middle of the neck.

The internal jugular vein will be found described on p. 1038.

Superficial Cervical Glands.—These are about six in number, and they lie upon the sterno-cleido-mastoid muscle, along the course of the external jugular vein, and beneath the superficial fascia and platysma myoides muscle. They receive their afferent lymphatics from the adjacent superficial structures, the occipital and mastoid glands, and some of those of the parotid and submaxillary lymphatic glands. Their efferent lymphatics pass to the deep cervical and supraclavicular glands.

Deep Cervical Fascia.—The deep cervical fascia is divided into (1) a superficial layer, which completely invests the neck in the form of a collar, and (2) deep processes or laminæ, which invest the muscles, viscera, and chief bloodvessels and nerves.

Superficial Layer.—This layer is attached posteriorly to the ligamentum nuchæ; superiorly to (1) the superior curved line of the occipital bone; (2) the mastoid process of the temporal bone; (3) the zygomatic arch; and (4) the base of the inferior maxilla, under cover of the platysma myoides, as far forwards as the symphysis; and inferiorly to the clavicle and upper border of the manubrium sterni, being pierced above the centre of the clavicle by the external jugular vein. Along the middle line of the neck anteriorly it is continuous with the superficial layer of the opposite side.

The superficial layer invests the cervical portion of the trapezius, and from the anterior border of that muscle it passes forwards over the posterior triangle of the neck to the posterior border of the sterno-cleido-mastoid. In doing so it furnishes a deep process, which ensheathes the posterior belly of the omo-hyoid muscle. This process also embraces the intervening tendon of that muscle, after which it passes downwards and inwards to be attached to the back of the inner end of the clavicle and the first rib. In this manner the horizontal position of the posterior belly of the omo-hyoid is accounted for. When the superficial layer of the deep cervical fascia reaches the posterior border of the sterno-cleido-mastoid it splits into two laminæ which ensheathe that muscle, the superficial lamina being underneath the external jugular vein and platysma myoides. At the anterior border of the sterno-cleido-mastoid the two laminæ reunite, and the fascia passes forwards over the anterior triangle of the neck to the median line, where it is continuous with the corresponding layer of the opposite side.

Between the upper part of the anterior border of the sterno-cleido-mastoid and the angle of the inferior maxilla the superficial layer is of considerable strength, and draws that border of the muscle forwards and upwards, so as to render it convex and keep it over the line of the leading vessels. Between the mastoid process and the angle of the inferior maxilla the superficial layer is prolonged upwards over the parotid gland as the parotid fascia, which is very dense, and is attached superiorly to the lower border of the zygomatic arch.

Below the level of the thyroid body the superficial layer divides into two laminæ, anterior and posterior, both of which are superficial to the depressor muscles of the hyoid bone. At the middle line these laminæ are continuous with those of the opposite side, and inferiorly they are attached to the anterior and posterior margins of the upper border of the manubrium sterni. Between them there is an interfascial interval, called the **suprasternal space,** or **space of Burns.** This interval contains areolar tissue, one or more lymphatic glands, the lower portions of the anterior

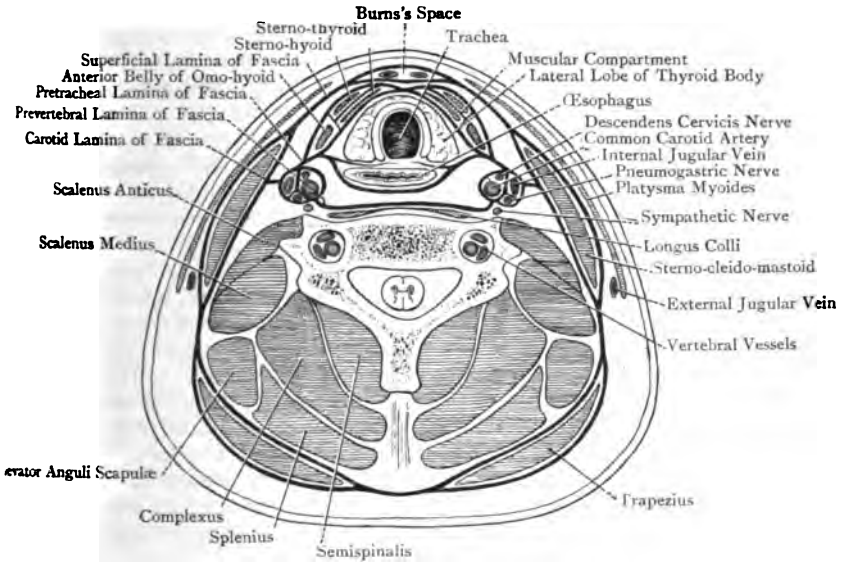


FIG. 425.—DIAGRAM OF A TRANSVERSE SECTION OF THE NECK AT THE LEVEL OF THE SEVENTH CERVICAL VERTEBRA, SHOWING THE ARRANGEMENT OF THE DEEP CERVICAL FASCIA, AND THE POSITIONS OF OTHER STRUCTURES.

jugular veins, with the transverse vessel which here connects them, and the sternal heads of the sterno-cleido-mastoid muscles.

Deep Processes or Laminæ.—The deep laminæ, as stated, invest the muscles, viscera, and chief bloodvessels and nerves. The most important are derived from that lamina of the superficial layer which forms the posterior wall of the sheath of the sterno-cleido-mastoid muscle, and they are three in number, namely, carotid, pretracheal, and prevertebral, all of which have an intimate initial connection.

The **carotid lamina** splits to form the carotid sheath, which contains, in separate compartments (1) the common carotid artery and descendens cervicis nerve, (2) the internal jugular vein, and (3) the

pneumogastric nerve, the latter being contained within the back part of the septum, which separates the artery from the vein.

The **pretracheal** or **visceral lamina,** which is at first intimately connected with the anterior wall of the carotid sheath, passes forwards behind the depressor muscles of the hyoid bone, in which situation it splits to ensheathe the thyroid body, trachea, and œsophagus, and then it passes to the median line, where it is continuous with the pretracheal lamina of the opposite side. The pretracheal lamina is attached superiorly to the body of the hyoid bone, and inferiorly it descends over the trachea and bloodvessels into the superior mediastinum of the thorax, where it blends with the fibrous layer of the pericardium.

The **prevertebral lamina,** which is at first intimately connected with the posterior wall of the carotid sheath, passes forwards behind the pharynx and œsophagus, and in front of the prevertebral muscles. It is known as the *prevertebral fascia.* At the middle line it is continuous with the corresponding lamina of the opposite side; superiorly it is attached to the base of the skull; and inferiorly it descends over the longus colli muscle into the posterior mediastinum of the thorax. Along a line corresponding to the inner wall of the carotid sheath the pretracheal lamina furnishes a secondary lamina, called the **bucco-pharyngeal fascia,** which covers the constrictor muscles of the pharynx and the buccinator muscle. Between the bucco-pharyngeal and prevertebral fasciæ there is an interval, called the **retro-pharyngeal space,** which contains the loosely arranged connective tissue uniting the two fasciæ. This space extends as high as the base of the skull, and inferiorly is continuous with the posterior mediastinum of the thorax. Another process of the prevertebral fascia passes downwards and outwards in front of the scalenus anticus muscle. Thereafter it invests the third part of the subclavian artery and subclavian vein, together with the nerve-trunks of the brachial plexus, and, passing behind the clavicle, it becomes continuous with the axillary sheath, which latter blends with the posterior aspect of the costo-coracoid membrane. In the region of the subclavian triangle there is an interfascial space between this process of the pretracheal fascia and the superficial layer of the deep cervical fascia. This space extends downwards behind the clavicle to the point where the axillary sheath and costo-coracoid membrane join. It contains the posterior belly of the omo-hyoid muscle, the suprascapular and transverse cervical vessels, the lower part of the external jugular vein, and the terminal portion of the anterior jugular vein.

Interfascial Compartments. — It has been stated that the deep cervical fascia reaches the median line of the neck anteriorly in three layers, namely, anterior or superficial in (two divisions), pretracheal, and prevertebral. It is therefore evident that there are four interfascial compartments, as follows: (1) the **suprasternal space,** or **space of Burns,** which is situated between the two divisions of the anterior or superficial layer, and contains the structures

already enumerated ; (2) the **muscular compartment,** which is situated between the anterior or superficial layer and the pretracheal layer, and contains the depressor muscles of the hyoid bone ; (3) the **visceral compartment,** which lies between the pretracheal and prevertebral layers, and contains the larynx, trachea, thyroid body, pharynx, œsophagus, and carotid sheath, the retro-pharyngeal space being in the subdivision of this compartment behind the bucco-pharyngeal fascia; and (4) the **vertebral compartment,** which lies between the prevertebral layer and the attachment of the fascia to the ligamentum nuchæ posteriorly, and contains the vertebral column, spinal cord, and prevertebral and postvertebral muscles.

The suprasternal and muscular compartments are shut off from the thoracic cavity. The visceral compartment, in front of the trachea, is continuous with the superior mediastinum of the thorax, and behind the œsophagus it, along with the retro-pharyngeal space, is continuous with the posterior mediastinum.

Parotid Process of the Deep Cervical Fascia.—This process is given off a little below the angle of the inferior maxilla, and it passes upwards on the deep surface of the parotid gland to the skull. Along with the parotid fascia superficial to the gland it forms a dense sheath which closely invests the glandular substance. The parotid process furnishes sheaths to the posterior belly of the digastric, styloid, and pterygoid muscles, and it also gives an investment to the superficial part of the submaxillary gland. Connected with the parotid process there are several bands, usually called ligaments, which are as follows : (1) spheno-mandibular ; (2) stylo-mandibular ; (3) pterygo-mandibular ; and (4) pterygo-spinous.

The **spheno-mandibular ligament** will be described in connection with the temporo-mandibular joint, of which it ranks as the internal lateral ligament.

The **stylo-mandibular ligament** extends from the styloid process of the temporal bone, near its tip, to the angle and adjacent part of the posterior border of the ramus of the inferior maxilla, where it is placed between the masseter and internal pterygoid muscles.

The **pterygo-mandibular ligament** is a narrow band which extends from the hamular process of the internal pterygoid plate of the sphenoid bone to the posterior extremity of the mylo-hyoid ridge of the inferior maxilla, close to the last molar alveolus. Anteriorly it gives origin to fibres of the buccinator muscle, and posteriorly to fibres of the superior constrictor muscle of the pharynx.

The **pterygo-spinous ligament** is a narrow band which extends from a sharp spine on the posterior border of the external pterygoid plate of the sphenoid bone, towards its upper part, to the spinous process of the sphenoid. This ligament is liable to become ossified.

Sterno-cleido-mastoid — *Origin.*—The **sternal head,** which is narrow and round, arises from the upper and outer part of the anterior surface of the manubrium sterni. It is tendinous in front,

and fleshy behind. The **clavicular head,** which is broad and flat arises from a rough ridge about 1½ inches long on the upper surface of the clavicle at its inner end, near the postero-superior border.

Insertion.—(1) The outer surface of the mastoid process of the temporal bone, and (2) the superior curved line of the occipital bone over about its outer half or two-thirds.

Nerve-supply.—(1) The spinal portion of the spinal accessory nerve, and (2) a branch from the cervical plexus, more particularly from the anterior primary division of the second cervical nerve.

The spinal portion of the spinal accessory nerve passes beneath the anterior border of the muscle fully 1 inch below the tip of the mastoid process, and, in passing downwards and backwards, it pierces the deep part of the muscle, giving off, as it does so, its branches to it.

The muscle is directed upwards, outwards, and backwards.

Action.—(1) To flex the head towards the side on which the muscle is placed, the face being turned towards the opposite side. This is the position of the head in *torticollis* or *wry-neck*, a condition which may be due to an organic contraction of the muscle, affecting both heads, or, it may be, the sternal head alone. (2) When both muscles act together from their origin they flex the head towards the thorax. (3) When both muscles act together from their insertion they elevate the upper part of the anterior thoracic wall in forced inspiration.

The sternal and clavicular heads are separated by a triangular cellular interval for a short distance above the sterno-clavicular joint, and before their junction the fibres of the clavicular head to a large extent pass behind those of the sternal head, so that overlapping takes place. The muscle is surrounded by a strong sheath, which is formed by the deep cervical fascia. The platysma myoides covers a large part of it, and the external jugular vein, the superficial cervical and great auricular nerves, and the superficial cervical glands are related to its superficial surface, under cover of the platysma myoides. The principal deep relations are as follows: in the lower part of the neck it covers the first and second parts of the subclavian artery, the sterno-hyoid, sterno-thyroid, omo-hyoid, and scalenus anticus muscles, with the phrenic nerve lying upon the last-named muscle. In this situation it also covers the anterior jugular vein, and the transverse cervical and suprascapular arteries. Higher up it covers the cervical plexus of nerves, the levator anguli scapulæ, scalenus medius, and scalenus posticus muscles, and the spinal portion of the spinal accessory and the hypoglossal nerves. At its insertion it covers the splenius capitis, trachelo-mastoid, and posterior belly of the digastric muscles, and a portion of the occipital artery, in this order from the surface downwards. The anterior border of the muscle forms the posterior boundary of the anterior triangle of the neck, and covers the carotid sheath, with its contents, as high as the level of the upper border of the thyroid cartilage; and above that level it covers the

external and internal carotid arteries. This border also overlaps slightly the lateral lobe of the thyroid body. The posterior border forms the anterior boundary of the posterior triangle of the neck, and along it there lie the following structures: the glandulæ concatenatæ, the small occipital nerve, great auricular, superficial cervical, spinal portion of the spinal accessory, and the descending superficial branches of the cervical plexus of nerves, and a portion of the external jugular vein.

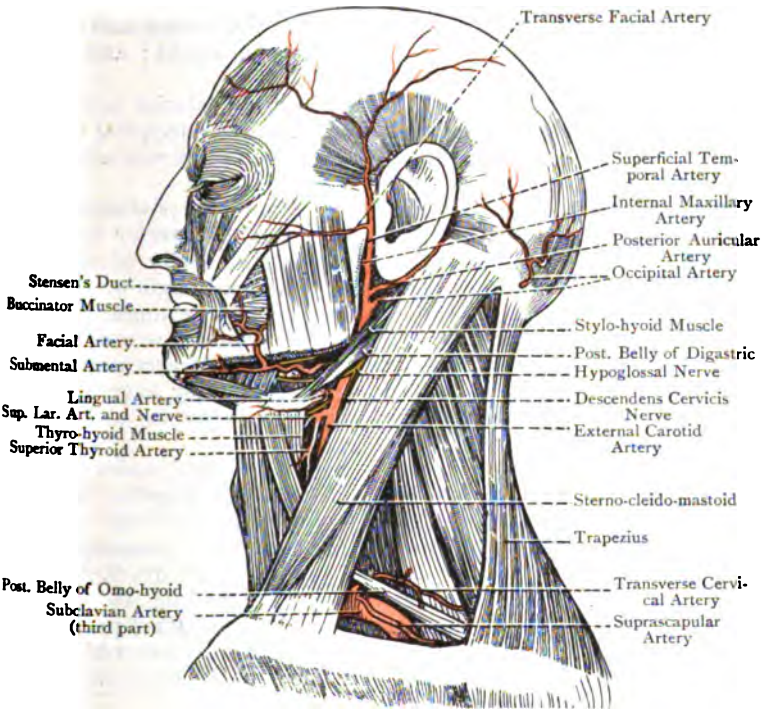


FIG. 426.—THE LEFT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed).

The sterno-cleido-mastoid muscle, from its diagonal position upon the side of the neck, divides the quadrilateral space into two triangles—posterior and anterior.

Posterior Triangle.—This is the region which lies behind the sterno-cleido-mastoid muscle.

Boundaries—*Anterior.*—The posterior border of the sterno-cleido-mastoid. *Posterior.*—The anterior border of the trapezius. *Inferior* (**base**).—The middle third of the clavicle. The **apex** is at

the superior curved line of the occipital bone, where the sterno-cleido-mastoid and trapezius may meet, but the apex is usually truncated. The **roof** is formed by the skin, superficial and deep fasciæ, and, for a short distance inferiorly, by the platysma myoides. The small occipital nerve lies in the upper part of the roof, and the descending superficial branches of the cervical plexus and the external jugular vein lie in the lower part of the roof. The **floor** is formed by the following muscles, in order from above downwards : (1) a small angle of the complexus, provided the trapezius is not well developed at the occiput ; (2) the splenius capitis ; (3) the levator anguli scapulæ ; (4) the scalenus medius and scalenus posticus ; (5) the posterior belly of the omo-hyoid ; and (6) the scalenus anticus.

The posterior triangle is subdivided by the posterior belly of the omo-hyoid into a large upper portion, called the occipital triangle, and a small lower portion, called the subclavian or supraclavicular triangle.

Occipital Triangle—Boundaries—*Anterior.*—The posterior border of the sterno-cleido-mastoid. *Posterior.*—The anterior border of the trapezius. *Inferior* (**base**).—The posterior belly of the omo-hyoid. The muscles in its floor are (1) a small angle of the complexus (inconstant), (2) splenius capitis, (3) levator anguli scapulæ, and (4) scaleni medius et posticus. The **contents** are the superficial branches of the cervical plexus, the spinal accessory nerve, the branches of the cervical plexus to the levator anguli scapulæ and trapezius, a small part of the occipital artery close to the apex, and the glandulæ concatenatæ.

Cervical Plexus.—The cervical plexus is situated under cover of the upper part of the sterno-cleido-mastoid muscle, and lies immediately in front of the slips of origin of the scalenus medius. It is formed by the anterior primary divisions of the first three cervical nerves and the greater part of that of the fourth, a small branch of the latter descending to join the anterior primary division of the fifth, and so taking part in the brachial plexus. Each of the anterior primary divisions of the first four cervical nerves is connected with the superior cervical ganglion of the sympathetic by a grey ramus communicans.

The *anterior primary division of the first cervical nerve* lies at first in the vertebrarterial groove of the atlas under cover of the vertebral artery. It then passes forwards in a groove on the outer surface of the superior articular process of the atlas, having the vertebral artery on its outer side. It next emerges between the rectus capitis lateralis muscle (to which it gives a branch) and the rectus capitis anticus minor, and descends in front of the root of the costal process of the atlas to join the ascending branch of the second nerve. From the loop so formed branches are given to the recti antici muscles, major and minor, and one or more branches pass to the hypoglossal nerve, the destination of their fibres being the descendens cervicis and thyro-hyoid nerves.

The *anterior primary divisions of the second, third, and fourth cervical nerves*, having emerged between the corresponding intertransversales muscles, divide each into an ascending and a descending branch, which unite with adjacent branches to form loops. The descending branch of the fourth nerve, as stated, joins the fifth, and enters into the brachial plexus. The cervical plexus is therefore a looped plexus, the number of loops being three.

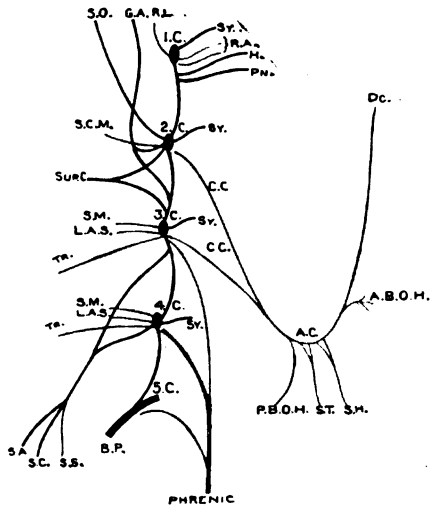


FIG. 427.—SCHEME OF THE CERVICAL PLEXUS OF NERVES.

The Descendens Cervicis Nerve is also shown.

1c, 2c, 3c, 4c, 5c. Anterior Primary Divisions of Upper Five Cervical Nerves
R.L. To Rectus Lateralis
G.A. Great Auricular
S.O. Small Occipital
S.C.M. To Sterno-cleido-mastoid
Sup.C. Superficial Cervical
S.M., S.M. To Scalenus Medius
L.A.S., L.A.S. To Levator Anguli Scapulæ
Tr., Tr. To Trapezius
S.A. Supra-acromial
S.C. Supraclavicular
S.S. Suprasternal
Sy. Branches to Sympathetic
R.A. To Rectus Capitis Anticus Major et Minor
H. To Hypoglossal
Pn. To Pneumogastric (Ganglion of Trunk)
C.C., C.C. Communicantes Cervicis
D.C. Descendens Cervicis
A.B.O.H. To Anterior Belly of Omo-hyoid
A.C. Ansa Cervicis
S.H. To Sterno-hyoid
S.T. To Sterno-thyroid
P.B.O.H. To Posterior Belly of Omo-hyoid

Branches.—These are divided into two groups—superficial and deep.

Superficial Group.—The nerves of this group are ascending, transverse, and descending.

The ascending and transverse nerves arise from the second and third cervical nerves.

The *ascending nerves* are the small occipital and great auricular (see p. 984). The *transverse nerve* is the superficial (transverse) cervical.

The **superficial** or **transverse cervical nerve** arises by two roots from the anterior primary divisions of the second and third cervical nerves, and, turning round the posterior border of the sterno-cleido-mastoid muscle, it passes forwards over the muscle, lying beneath the platysma myoides and the external jugular vein. Having reached the anterior triangle of the neck, it divides into two branches, upper and lower, which are distributed to the integument over the anterior triangle. The offsets of the upper branch communicate freely with the inframandibular branch of the facial nerve beneath the platysma myoides.

The *descending nerves* are the suprasternal, supraclavicular, and supra-acromial, and they arise in common from the third and fourth cervical nerves. As they descend they form distinct nerves, which lie in the roof of the subclavian triangle under cover of the platysma myoides. For their distribution, see p. 279.

Deep Group.—The nerves of this group are arranged in two sets—external and internal.

External Set.—The nerves of this set are muscular. (1) The second nerve furnishes a branch to the sterno-cleido-mastoid, which communicates in that muscle with the branch of the spinal portion of the spinal accessory nerve. (2) The third and fourth nerves furnish (*a*) two branches to the trapezius, which communicate in a plexiform manner with the spinal portion of the spinal accessory nerve beneath the upper part of the muscle; (*b*) two branches to the levator anguli scapulæ; and (*c*) branches to the scalenus medius.

Internal Set.—The nerves of this set are communicating and muscular.

The *communicating branches* are as follows: (1) connecting branches (grey rami communicantes) pass from the upper cervical ganglion of the sympathetic; (2) communicating branches pass to the pneumogastric and hypoglossal nerves from the highest loop of the plexus; and (3) two rami communicantes cervicis pass from the second and third nerves forwards and downwards, usually over, but sometimes underneath, the internal jugular vein, and terminate by joining the descendens cervicis, conjointly or separately, thus forming the ansa cervicis (ansa hypoglossi).

The *muscular branches* are distributed to the rectus capitis lateralis, recti antici, major and minor, upper part of the scalenus anticus, longus colli, and the diaphragm. The nerve to the diaphragm is the phrenic nerve (internal respiratory nerve), and, from its importance, it requires a special description.

The phrenic nerve arises, as a rule, by two roots, the larger of which is derived from the anterior primary division of the *fourth* cervical nerve, and the other from that of the third. In some cases the fifth cervical nerve, which enters into the brachial plexus, furnishes an additional small root. In the neck the nerve descends upon the scalenus anticus muscle, which it crosses obliquely downwards and inwards, passing beneath the tendon of the omo-hyoid muscle, the transverse cervical and supra-

scapular arteries, and the anterior jugular vein. At the root of the neck the nerve, having left the scalenus anticus, passes behind the terminal part of the subclavian vein, and crosses *over* the internal mammary artery from without inwards. Having come into contact with the inner surface of the dome of the pleura, it disappears behind the inner end of the clavicle, and enters upon the thoracic part of its course (see p. 885).

The *right* nerve at the root of the neck is superficial to the second part of the right subclavian artery, with the intervention of the scalenus anticus muscle. The *left* nerve at the root of the neck is anterior and parallel to the first part of the left subclavian artery, and lies behind the terminal part of the thoracic duct.

The phrenic nerve is sometimes reinforced towards the root of the neck by a branch from the nerve to the subclavius muscle, and, when this takes place, the root from the fifth cervical nerve is usually absent. Before leaving the neck the phrenic nerve receives a twig from the middle, or lower, cervical ganglion of the sympathetic.

No branches arise from the phrenic nerve in the neck.

Suprascapular Glands.—These are three or four in number, and are situated over the subclavian triangle. They are continuous superiorly with the glandulæ concatenatæ, and inferiorly with the external axillary glands. They receive their afferent lymphatics from the adjacent parts of the neck, the acromial region, the lower superficial cervical glands, the upper part of the pectoral region, and, it may be, from the upper part of the mammary gland. Their efferent lymphatics pass to the jugular lymphatic trunk.

Subclavian or Supraclavicular Triangle.—The subclavian triangle is the lower division of the posterior triangle of the neck, and is separated from the upper division, or occipital triangle, by the posterior belly of the omo-hyoid muscle. It is situated above the middle third of the clavicle, and is of small size until the deep cervical fascia, which ensheathes the posterior belly of the omo-hyoid, has been divided.

Boundaries—*Superior.*—The posterior belly of the omo-hyoid muscle. *Inferior.*—The middle third of the clavicle. *Anterior.*—The clavicular part of the sterno-cleido-mastoid muscle. *Roof.*—The skin ; superficial fascia and platysma myoides muscle ; supra-sternal, supraclavicular, and supra-acromial nerves ; a part of the external jugular vein ; and the deep cervical fascia. *Floor.*—The scalenus medius and scalenus posticus muscles.

The extent of the triangle is affected by (1) the height to which the posterior belly of the omo-hyoid ascends above the clavicle, and (2) the extent of the clavicular attachments of the sterno-cleido-mastoid and trapezius muscles. The depth of the triangle is influenced by the position of the shoulder, being greater when the shoulder is raised and carried forwards, and less when it is depressed and carried backwards.

Contents.—The contents are as follows : (1) the greater portion of the third part of the subclavian artery ; (2) small portions of the

transverse cervical artery and vein ; (3) the lower portion of the external jugular vein ; (4) the nerve-trunks of the brachial plexus ; and (5) the nerve to the subclavius muscle, and the suprascapular and posterior thoracic nerves.

Third Part of the Subclavian Artery.—This part of the vessel extends from the outer border of the scalenus anticus muscle to the outer border of the first rib, where it becomes the axillary artery. Its course is downwards and outwards, and, for the greater part of its extent, it lies in the subclavian triangle. Subsequently, however, it passes under cover of the clavicle and subclavius muscle.

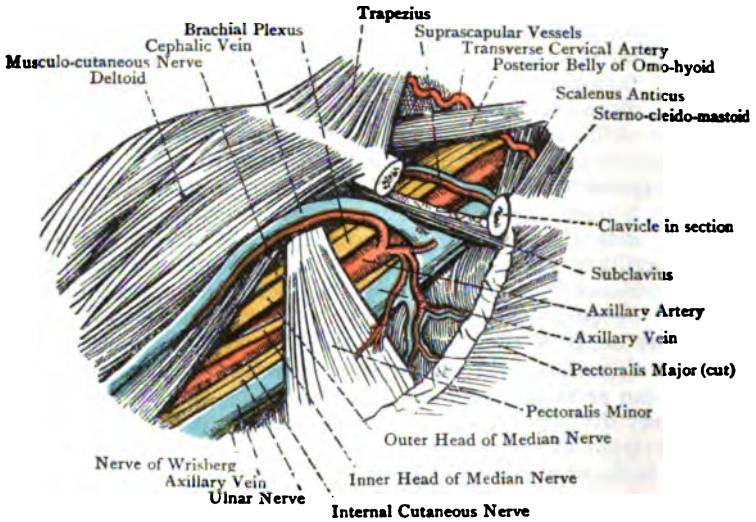


FIG. 428.—THE AXILLARY SPACE, AFTER REFLECTION OF THE PECTORALIS MAJOR; AND THE SUBCLAVIAN TRIANGLE.

Relations—*Anterior.*—The skin ; superficial fascia and platysma myoides ; suprasternal, supraclavicular, and supra-acromial nerves ; deep cervical fascia ; clavicle and subclavius muscle ; transverse cervical vessels ; suprascapular vessels ; nerve to the subclavius muscle ; and the terminal portion of the external jugular vein. The last-named vessel crosses in front of the artery close to the sterno-cleido-mastoid muscle, and in this situation is joined by the transverse cervical and suprascapular veins. A plexiform arrangement of veins is sometimes met with over the artery, which may be rendered more complex by a branch ascending over the clavicle from the cephalic vein. *Posterior.*—The scalenus medius, with the close intervention of the lower nerve-trunk of the brachial plexus. *Superior.*—The upper and middle nerve-trunks of the brachial plexus, the latter being nearest the vessel. *Inferior.*—

The upper surface of the first rib and the subclavian vein, the vein being on a more anterior plane than the artery, and lying behind the clavicle.

The third part of the subclavian artery does not usually furnish any branch. In some cases, however, the *posterior scapular artery* arises from it, instead of from the transverse cervical branch of the thyroid axis from the first part of the subclavian. In these cases the posterior scapular artery passes outwards between the nerve-trunks of the brachial plexus.

The **direction** of the third part of the artery is indicated by a line drawn from a point on the posterior border of the sterno-cleido-mastoid muscle, about ½ inch above the clavicle, to the centre of that bone. The artery is accessible to compression as it passes over the first rib, the guide to it at this point being the centre of the clavicle. In ligation of the artery the guide to it is the scalene tubercle or spine (tubercle of Lisfranc) on the inner border of the first rib, behind which tubercle the vessel lies; and the scalenus anticus muscle, which is usually covered by the clavicular part of the sterno-cleido-mastoid, leads to this tubercle.

For the manner in which the collateral circulation is carried on after ligation of the third part of the subclavian artery, see p. 304.

The **subclavian vein,** in the region of the subclavian triangle, is situated behind the clavicle, where it lies below and anterior to the artery. On the upper surface of the first rib it is anterior to the scalenus anticus, and it receives the external jugular vein, and in some cases the anterior jugular vein.

The **transverse cervical artery** lies in the subclavian triangle for a short distance only, close to where the posterior belly of the omo-hyoid passes beneath the sterno-cleido-mastoid. It passes outwards beneath the former muscle into the lower part of the occipital triangle, where it divides into its superficial cervical and posterior scapular branches, the former entering the trapezius, and the latter passing beneath the levator anguli scapulæ, after which it descends along the base of the scapula, under cover of the rhomboid muscles.

The **transverse cervical vein** opens into the external jugular vein, there being a valve at, or near, its ending.

The **suprascapular artery** is not in the subclavian triangle, but lies behind the clavicle, close to its upper aspect. It will be described in connection with the first part of the subclavian artery (see p. 1067).

The **suprascapular vein** also lies behind the clavicle, and it opens into the external jugular vein, there being a valve at, or near, its ending.

The external jugular vein will be found described on p. 1009.

Brachial Plexus.—The brachial plexus is situated in the lower part of the posterior triangle of the neck, behind the clavicle, and in the upper part of the axilla. Its complex formation is rendered simple by arranging it into four stages, namely (1) nerve-roots, (2) nerve-trunks, (3) divisions of nerve-trunks, and (4) nerve-cords.

First Stage.—The nerves which form the plexus are the anterior primary divisions of the fifth, sixth, seventh, and eighth cervical, and the greater part of that of the first thoracic. Superiorly the plexus is reinforced by a small descending branch from the fourth cervical, which joins the fifth, and inferiorly it is occasionally reinforced by a branch from the second thoracic, which joins the first. As regards the first thoracic nerve, the part of it which does not join the plexus, and which is of small size, enters the first intercostal space to become the first intercostal nerve. The nerves, as they

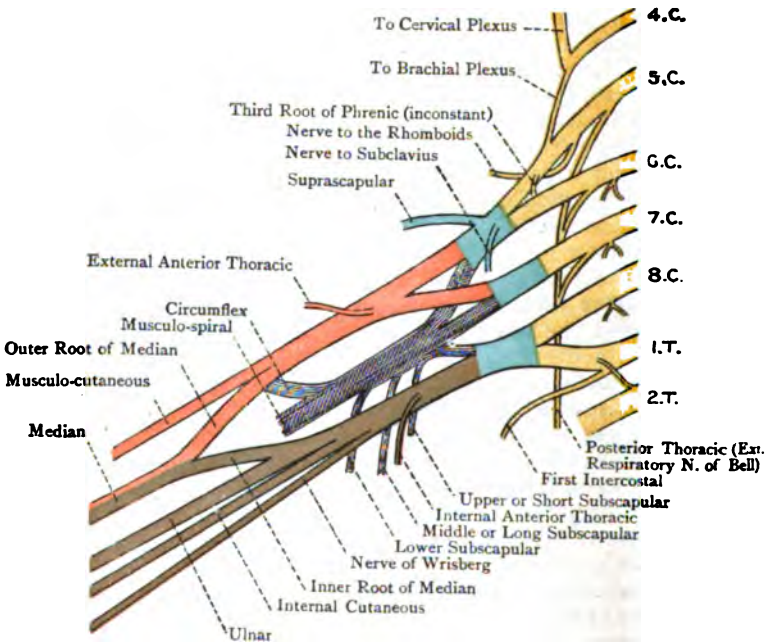


FIG. 429.—THE BRACHIAL PLEXUS.

(Yellow = Spinal Nerves and their Branches; Blue = Trunks; Red = Outer Cord; Purple = Inner Cord; Grey = Posterior Cord.)

emerge at the side of the neck, are placed between the scalenus anticus and scalenus medius.

Second Stage.—The fifth and sixth cervical nerves join at the outer border of the scalenus anticus to form the **upper trunk**; the seventh cervical remains meanwhile single, and forms the **middle trunk**; and the eighth cervical and greater part of the first thoracic unite between the scalene muscles to form the **lower trunk.** There are thus three trunks—upper, middle, and lower.

Third Stage.—A little above the clavicle each of the three trunks breaks up into an anterior and a posterior division.

Fourth Stage.—The anterior divisions of the upper and middle trunks unite to form the **outer cord** of the plexus; the anterior division of the lower trunk, which is of large size, forms the **inner cord**; and all three posterior divisions (that of the lower trunk being of small size) unite to form the **posterior cord.** As a variety, the anterior division of the middle trunk may subdivide into two branches, one entering the outer cord and the other the inner. There are thus three cords—outer, inner, and posterior.

Branches of the Plexus.—The branches are conveniently divided into two groups—supraclavicular, arising above the clavicle, and coming from nerve-roots and nerve-trunks; and infraclavicular, arising below the clavicle, and coming from nerve-cords.

Supraclavicular Branches.—These are as follows: **Muscular branches** from the four cervical nerves to the scalene muscles and longus colli.

One root of the phrenic nerve (inconstant) from the front of the fifth cervical.

The Nerve to the Rhomboids.—This branch arises from the back of the fifth cervical, close to or along with the highest root of the posterior thoracic, and it takes a backward course through the scalenus medius.

The Posterior Thoracic Nerve or External Respiratory Nerve of Bell.—This branch arises by three roots from the back of the fifth, sixth, and seventh cervical nerves. The upper two roots pierce the scalenus medius muscle below the nerve to the rhomboids, either conjointly or separately, whilst the lowest root passes in front of the scalenus medius, and joins the trunk formed by the others near the first rib. The nerve then courses behind the brachial plexus and the first part of the axillary artery to the axillary surface of the serratus magnus, which it supplies.

The Nerve to the Subclavius.—This small branch arises from the front of the upper trunk, its fibres being derived from the fifth cervical. It descends over the third part of the subclavian artery, and, passing behind the clavicle, it enters the subclavius muscle on its deep aspect. This nerve sometimes communicates with the phrenic nerve.

The Suprascapular Nerve.—This is a large nerve which arises from the back of the upper trunk, its fibres being derived from the fifth and sixth cervical. It is directed downwards, outwards, and backwards beneath the trapezius and posterior belly of the omo-hyoid to the upper border of the scapula, on approaching which it gets in company with the suprascapular artery. It is distributed to the supraspinatus and infraspinatus muscles and shoulder-joint.

For the infraclavicular branches of the brachial plexus, see p. 294.

Anterior Triangle.—This triangle is situated in front of the sterno-cleido-mastoid muscle, and its base is directed upwards.

Boundaries—*Anterior.*—The middle line of the neck, that is to say, a line extending from the chin to the upper border of the manubrium sterni. *Posterior.*—The anterior border of the sterno-

cleido-mastoid muscle. *Superior.*—One half of the base of the inferior maxilla, and a line drawn from the angle of that bone to the mastoid process. The triangle is covered by the skin, superficial cervical fascia, platysma myoides, and deep cervical fascia. Superficial to the deep fascia there are the following structures: the anterior jugular vein, the ramifications of the superficial or

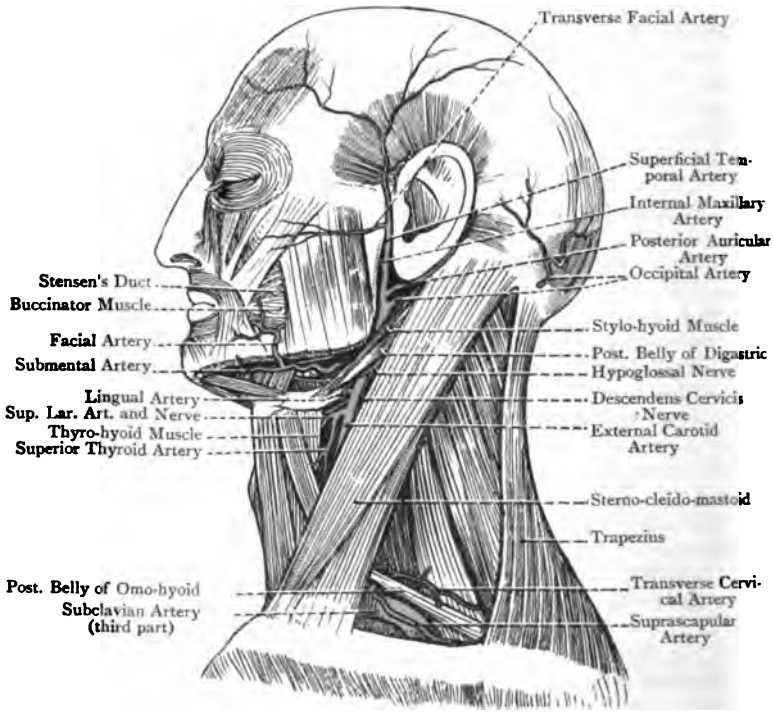


FIG. 430.—THE LEFT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed).

transverse cervical nerve, and the inframandibular branch of the facial nerve.

The anterior triangle is divided into three triangles by the anterior belly of the omo-hyoid muscle inferiorly, and the two bellies of the digastric muscle superiorly. The subdivisions from below upwards are called muscular, carotid, and digastric or submaxillary.

The **muscular triangle** (inferior carotid) is bounded *anteriorly* by the middle line of the neck; *posteriorly* by the anterior border of the sterno-cleido-mastoid; and *superiorly* by the anterior belly of the omo-hyoid.

The **carotid triangle** (superior carotid) is bounded *inferiorly* by the anterior belly of the omo-hyoid; *superiorly* by the posterior belly of the digastric and stylo-hyoid; and *posteriorly* by the anterior border of the sterno-cleido-mastoid.

The **digastric** or **submaxillary triangle** is bounded *postero-inferiorly* by the posterior belly of the digastric and stylo-hyoid; *antero-inferiorly* by the anterior belly of the digastric; and *superiorly* by one half of the base of the inferior maxilla, and a line drawn from the angle of that bone to the mastoid process.

Contents of the Triangles—Muscular Triangle.—The area of this triangle is occupied by the sterno-hyoid and sterno-thyroid muscles; hence the name muscular triangle. Under cover of these muscles there are the carotid sheath with its contents, the lateral lobe of the thyroid body, the trachea, and the larynx. The œsophagus lies behind the trachea, with a slight inclination towards the left side at the root of the neck, and the inferior or recurrent laryngeal nerve lies in the groove between the trachea and the œsophagus. The inferior thyroid artery pursues a tortuous course inwards behind the lower part of the carotid sheath, and the gangliated cord of the sympathetic descends behind the sheath.

Carotid Triangle.—This triangle contains the upper part of the common carotid, and the commencements of the external and internal carotid, arteries, all of these being overlapped by the anterior border of the sterno-cleido-mastoid, when the deep fascia which ensheathes that muscle is undisturbed. The common carotid and internal carotid arteries, together with the pneumogastric nerve, are contained within the carotid sheath, and the descendens cervicis nerve lies upon the sheath, or within it, being situated in either case over the common carotid artery. The sterno-cleido-mastoid artery and the superior thyroid vein cross the sheath near the bifurcation of the common carotid artery, and the carotid body lies behind the vessel about the same level. The deep cervical glands lie along the course of the internal jugular vein. The origins of the superior thyroid, lingual, facial, and occipital arteries are contained in this triangle, and the ascending pharyngeal branch of the external carotid lies deeply between that vessel and the internal carotid. The internal jugular vein in this triangle receives the common facial, lingual, and superior thyroid veins. The hypoglossal nerve lies along the lower border of the posterior belly of the digastric muscle, and it here gives off, from behind forwards, the descendens cervicis and thyro-hyoid nerves, the former passing downwards over, or within, the carotid sheath, and the latter passing forwards and downwards at an acute angle with the parent trunk. The internal branch of the superior laryngeal nerve lies deeply behind the bloodvessels, and the external laryngeal branch of that nerve descends internal to them, and passes beneath the depressor muscles of the hyoid bone. The pneumogastric nerve is within the carotid sheath, and the gangliated cord of the sympathetic is behind it. The spinal portion of

the spinal accessory nerve lies deeply, its course being downwards and backwards beneath the sterno-cleido-mastoid, the deep portion of which it pierces.

Digastric or Submaxillary Triangle.—This triangle is divided into two parts, anterior and posterior, by the stylo-mandibular ligament. The anterior part contains the superficial part of the submaxillary gland, the facial vein being superficial to it, and the facial artery being embedded in its upper and back part. In this triangle the facial artery gives off its inferior or ascending palatine, tonsillar, glandular, and submental branches. The muscles in the floor of the anterior part of the triangle are the mylo-hyoid, and a part of the hyo-glossus. The superficial part of the submaxillary gland rests upon the mylo-hyoid muscle, and conceals the mylo-hyoid nerve and submental artery, which are in direct contact with the muscle. The hypoglossal nerve lies upon that part of the hyo-glossus muscle which appears in the anterior part of the triangle, but it soon disappears beneath the posterior free border of the mylo-hyoid muscle, in company with the deep part of the submaxillary gland and the lingual nerve. The posterior part of the digastric triangle contains a portion of the parotid gland, and under cover of this part is the external carotid artery, which here furnishes its posterior auricular branch.

The anterior jugular vein and the superficial or transverse cervical nerve have been already described (see pp. 1008 and 1018). The inframandibular branch of the facial nerve will be found described on p. 1098.

Lymphatic Glands.—The **submaxillary lymphatic glands** are situated beneath the deep cervical fascia near the base of the inferior maxilla, over the digastric triangle, and are about six in number. They receive their afferent lymphatics from the front part of the tongue, the lateral part of the floor of the mouth, the side of the nose, the upper lip, the outer part of the lower lip, and the submaxillary and sublingual salivary glands. Their efferent lymphatics pass to the superficial, and superior group of the deep cervical, glands.

The **suprahyoid** or **submental glands** are situated beneath the chin in the submental triangle, and are two or three in number. They receive their afferent lymphatics from the tip of the tongue, the front of the floor of the mouth, and the inner part of the lower lip; and their efferent lymphatics pass to the submaxillary lymphatic glands.

The **prelaryngeal glands,** when present, are situated in front of the crico-thyroid membrane, and are one or two in number. They receive their afferent lymphatics from the interior of the larynx, below the rima glottidis, and from the adjacent part of the thyroid body. Their efferent lymphatics pass to the inferior group of deep cervical glands.

The **pretracheal glands** lie in front of the cervical portion of the trachea, from which, as well as from the adjacent part of the

thyroid body, they receive their afferent lymphatics. Their efferent lymphatics pass to the inferior group of deep cervical glands.

Occasionally a few lymphatic glands are met with along the course of the anterior jugular vein.

Deep Cervical Glands.—These glands lie beneath the sterno-cleido-mastoid muscle, and are about twenty-five in number. They are arranged in two groups, superior and inferior.

The *superior group* lie along the internal jugular vein above the level of the upper border of the thyroid cartilage. They receive their afferent lymphatics from the cranial cavity, the internal maxillary glands, some of the parotid and submaxillary lymphatic glands, the root of the tongue, the upper part of the thyroid body, the larynx, and the lower part of the pharynx. Their efferent lymphatics pass to the glands of the inferior group.

The *inferior group* lie along the lower part of the internal jugular vein, and extend outwards and backwards beneath the sterno-cleido-mastoid, as far as its posterior border, where they give rise to a chain known as the *glandulæ concatenatæ*. The glands of this chain are continuous inferiorly with the supraclavicular glands, and, through these, with the external axillary glands. They receive their afferent lymphatics from the superior group of deep cervical glands, the upper superficial cervical glands, the lower part of the thyroid body, and the cervical portions of the trachea and œsophagus. Their efferent lymphatics unite to form a single vessel, called the **jugular lymphatic trunk,** which opens on the left side into the thoracic duct, and on the right side into the right lymphatic duct.

Infrahyoid Muscles.—These are four in number, on either side, as follows: the omo-hyoid, sterno-hyoid, sterno-thyroid, and thyro-hyoid.

Omo-hyoid.—This muscle consists of two bellies, anterior and posterior, and an intervening tendon. *Origin.*—By means of the **posterior belly** from (1) the upper border of the scapula close to the inner side of the suprascapular notch, and (2) the supra-scapular or transverse ligament, which bridges over the supra-scapular notch.

Insertion.—By means of the **anterior belly** into the outer third of the lower border of the body of the hyoid bone, immediately external to the insertion of the sterno-hyoid muscle.

Nerve-supply.—The anterior belly is supplied by the descendens cervicis nerve, and the posterior belly derives its branches from the ansa cervicis (ansa hypoglossi).

The posterior belly is contained in the posterior triangle of the neck, and separates the occipital from the subclavian or supra-clavicular triangle. Its course is forwards and slightly upwards, and it passes beneath the sterno-cleido-mastoid muscle, where its fibres terminate in the intervening tendon. It is ensheathed by a deep process of the deep cervical fascia, as that fascia crosses the

posterior triangle, and this process is attached to the back of the inner end of the clavicle and the first rib, which explains the almost horizontal position occupied by the posterior belly.

The anterior belly proceeds from the intervening tendon, and passes upwards and slightly inwards to the body of the hyoid bone. As it emerges from beneath the anterior border of the sterno-cleido-mastoid muscle the anterior belly crosses the carotid sheath on a level with the narrow anterior part of the cricoid cartilage, and in the anterior triangle of the neck it forms the separation between the muscular (inferior carotid) and carotid (superior carotid) triangles.

Sterno-hyoid—*Origin.*—(1) The posterior surface of the manubrium sterni at its upper and outer part; (2) the posterior sterno-clavicular ligament; and, it may be, (3) the posterior surface of the clavicle at its inner end.

Insertion.—The inner two-thirds of the lower border of the body of the hyoid bone, extending from the middle line to the insertion of the anterior belly of the omo-hyoid.

Nerve-supply.—The ansa cervicis (ansa hypoglossi).

The muscle is flat and ribbon-like, and rests upon the sterno-thyroid and thyro-hyoid.

Sterno-thyroid—*Origin.*—(1) The posterior surface of the manubrium sterni at its upper and outer part, below the origin of the sterno-hyoid; and (2) the posterior surface of the first costal cartilage.

Insertion.—The oblique line on the outer surface of the ala of the thyroid cartilage.

Nerve-supply.—The ansa cervicis (ansa hypoglossi).

The muscle is broader, but shorter, than the sterno-hyoid, underneath which it lies. Within the thorax the right muscle lies in front of the innominate artery, and the left in front of the left common carotid artery and left innominate vein. In the neck each muscle rests upon the carotid sheath and the corresponding lateral lobe of the thyroid body.

The sterno-hyoid muscles as they emerge from the thorax are separated by an interval, in which situation the sterno-thyroid muscles lie in close contact. As the muscles ascend, the sterno-hyoids converge, but the sterno-thyroids diverge.

Thyro-hyoid—*Origin.*—The oblique line on the outer surface of the ala of the thyroid cartilage.

Insertion.—(1) The outer half of the lower border of the body of the hyoid bone; and (2) the basal half of the great cornu of that bone.

Nerve-supply.—The thyro-hyoid nerve, which is a special branch of the hypoglossal. The nerve enters the deep surface of the muscle close to its posterior border.

The muscle is quadrilateral. Its superficial surface supports the anterior belly of the omo-hyoid and the sterno-hyoid muscles, and its deep surface is related to the ala of the thyroid cartilage,

the thyro-hyoid membrane, the internal branch of the superior laryngeal nerve, and the superior laryngeal artery.

The nerves which supply the infrahyoid group of muscles are regarded as being of spinal origin.

Action of the Infrahyoid Muscles—**Omo-hyoid.**—(1) To depress the hyoid bone ; and (2) to render tense the deep cervical fascia in the lower part of the neck.

Sterno-hyoid.—To depress the hyoid bone.

Sterno-thyroid.—To depress the thyroid cartilage.

Thyro-hyoid.—(1) To depress the hyoid bone ; and (2) to elevate the thyroid cartilage, as in the production of high notes, or in deglutition.

Structures in the Median Line of the Neck.—The median line of the neck is divisible into two regions, suprahyoid and infrahyoid.

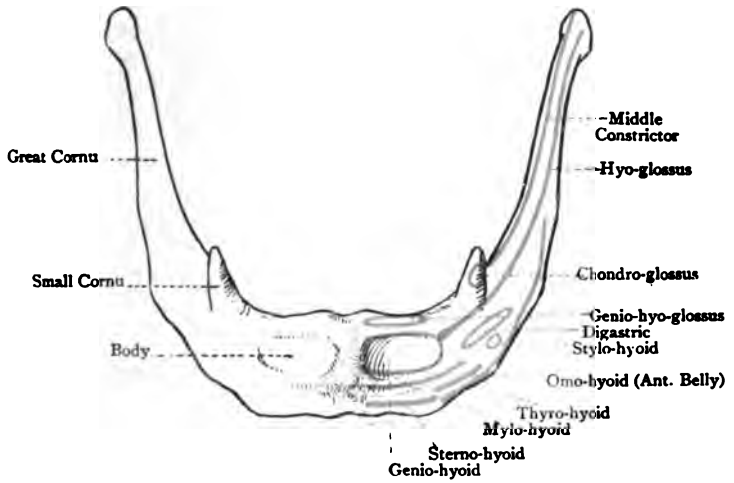


FIG. 431.—THE HYOID BONE, SHOWING ITS MUSCULAR ATTACHMENTS.

Suprahyoid Region.—The innermost fibres of the two platysma myoides muscles decussate at the median line for a short distance below the chin. On either side of the median line, under cover of the platysma myoides, is the anterior belly of the digastric muscle. The anterior bellies of opposite sides are near each other at the chin, but, as they descend with an inclination outwards, they diverge from each other and leave between them a triangular interval, called the **submental triangle.** The base of this triangle is formed by the body of the hyoid bone, and each lateral boundary is constructed by the anterior belly of the digastric, the apex being placed at the chin. The area of the triangle is occupied by the anterior portions of the mylo-hyoid muscles, which meet at the median line in a tendinous raphé, and superficial to these muscles

there are the suprahyoid or submental glands. Immediately underneath the mesial portions of the mylo-hyoid muscles are the genio-hyoid muscles, these two latter muscles being in very close contact at the median line. Beneath each genio-hyoid muscle is the inferior portion of the genio-hyo-glossus.

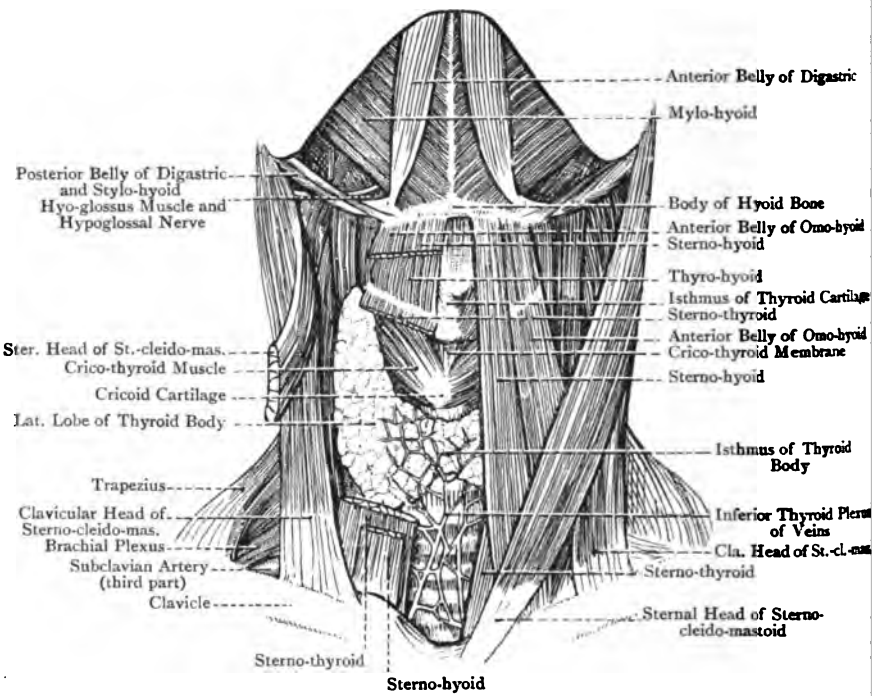


FIG. 432.—DISSECTION OF THE FRONT OF THE NECK.

(The area bounded on either side by the Anterior Belly of the Digastric and below by the body of the Hyoid Bone is the Submental Triangle.)

The relation of structures in the suprahyoid region, from the surface downwards (in a deep direction), is as follows :

1. Platysma myoides.
2. Mylo-hyoid.
3. Genio-hyoid.
4. Genio-hyo-glossus.

Infrahyoid Region.—The region from the hyoid bone downwards to the interclavicular notch on the upper border of the manubrium sterni is of considerable importance in connection with bronchocele or goitre, laryngotomy, and tracheotomy.

The **body of the hyoid bone** is a well-marked structure, along with the **great cornu** on either side of it. Below the hyoid bone there is

the **thyro-hyoid membrane,** which passes upwards within the lower border of the hyoid bone. The next structure is the **thyroid cartilage,** the upper border of which presents a well-marked median notch, whilst its two alæ form by their union the prominent **isthmus,** or *pomum Adami*.

Succeeding to the thyroid cartilage there is a narrow interval, which is occupied by the **crico-thyroid membrane,** and immediately below this membrane is the narrow anterior part of the **cricoid**

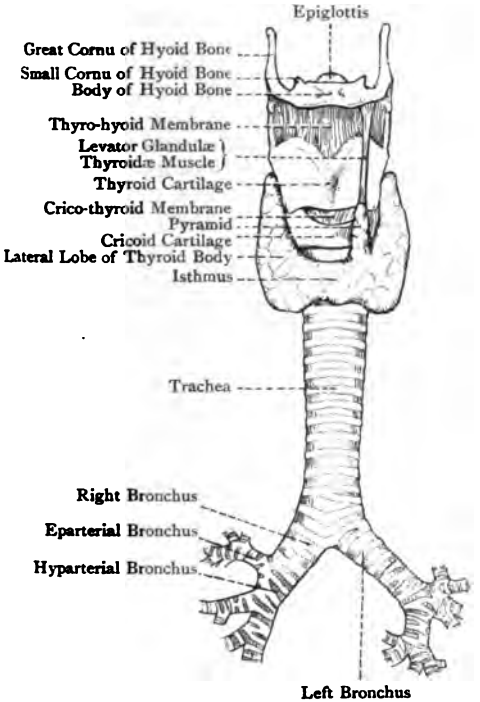


FIG. 433.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (ANTERIOR VIEW).

cartilage. The crico-thyroid membrane is only exposed close to the median line, being elsewhere covered by the two crico-thyroid muscles. The exposed part of the membrane is crossed by the *crico-thyroid arterial arch*, which is situated midway between the thyroid and cricoid cartilages, and lying upon the membrane there may be one or two prelaryngeal lymphatic glands. Laryngotomy may be performed in the crico-thyroid region, and the crico-thyroid arterial arch has to be borne in mind.

Succeeding to the cricoid cartilage is the **trachea,** which, as it descends, inclines backwards, and therefore becomes somewhat

inaccessible. The **thyroid body** is intimately related to it superiorly. Each *lateral lobe* closely embraces it laterally as low as about the fifth ring, and the *isthmus* lies in front of the second and third rings as a rule, but its position is liable to variation. Crossing the upper border of the isthmus there is one of the branches of the superior thyroid artery, known as the *artery of the isthmus*.

There is nothing of any importance in front of the trachea above the isthmus of the thyroid body. Below the isthmus there is a more or less copious plexus of veins, called the *inferior thyroid plexus*, from which the right and left inferior thyroid veins descend. Occasionally a small artery, called the *arteria thyroidea ima*, ascends directly in front of this part of the trachea, in the median line, to reach the isthmus of the thyroid body. The innominate, and even the right common carotid, artery, and the left innominate vein sometimes encroach upon the front of the trachea towards the root of the neck. In early life the upper part of the **thymus body** covers the front of the trachea. The foregoing structures are covered by the sterno-thyroid and sterno-hyoid muscles in the following manner: the two sterno-thyroid muscles are in contact with each other for a short distance above the manubrium sterni, so as to cover the trachea, but the two sterno-hyoid muscles are here separated by an interval; superiorly the two sterno-thyroid muscles diverge, and the two sterno-hyoid muscles come very nearly together.

The operation performed upon the trachea is tracheotomy. According as it is performed above or below the isthmus of the thyroid body, it is spoken of as the high operation, or the low operation. In the high operation there is no anatomical obstacle, unless it be a close attachment of the isthmus of the thyroid body to the tracheal rings which it covers. In the low operation the following obstacles are presented: (1) the trachea is here less accessible, because it recedes from the surface; (2) the inferior thyroid plexus of veins might prove troublesome; (3) an arteria thyroidea ima may be present; (4) the innominate and right common carotid arteries, and the left innominate vein may be endangered; and (5) in young children the thymus body would be in the way.

Descendens Cervicis (Descendens Hypoglossi) Nerve.—The descendens cervicis nerve arises from the hypoglossal nerve as the latter hooks round the occipital artery, its fibres being derived from the communicating branch which the hypoglossal receives from the loop between the first and second cervical nerves. The nerve, which is long, passes downwards and slightly forwards, lying upon, or within, the carotid sheath, and in either case directly over the line of the common carotid artery. Before reaching the centre of the neck it furnishes a branch to the anterior belly of the omo-hyoid muscle. Thereafter it is joined by a branch which is formed by the union of the two *rami communicantes cervicis* from the anterior primary divisions of the second and third cervical nerves. These two rami, however, sometimes join it separately. In this manner a loop is formed, which is called the **ansa cervicis**

(ansa hypoglossi). The convexity of the loop is directed downwards, and from it branches are given off to (1) the sterno-hyoid, (2) the sterno-thyroid, and (3) the posterior belly of the omo-hyoid, muscles.

The fibres of the descendens cervicis nerve are regarded as being of spinal, not hypoglossal, origin.

For the rami communicantes cervicis, see p. 1018.

Thyro-hyoid Nerve.—This nerve, which is composed of spinal fibres, derived from the loop between the first and second cervical nerves, arises from the hypoglossal at the lower border of the

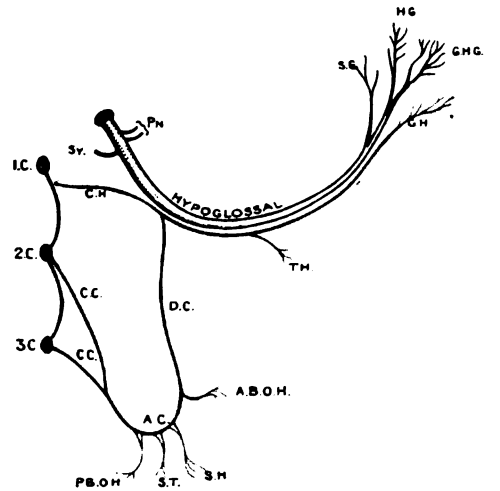


FIG. 434.—SCHEME OF THE HYPOGLOSSAL NERVE, SHOWING ITS CONNECTIONS WITH CERVICAL SPINAL NERVES.

SY. Twig from Sympathetic	S.H. To Sterno-hyoid
PN. Communicating with Pneumogastric	S.T. To Sterno-thyroid
1C, 2C, 3C. First, Second, and Third Cervical	P.B.O.H. To Posterior Belly of Omo-hyoid
C.H. Communicans Hypoglossi	T.H. To Thyro-hyoid
C.C. Communicantes Cervicis	G.H. To Genio-hyoid
D.C. Descendens Cervicis	G.H.G. To Genio-hyo-glossus
A.B.O.H. To Anterior Belly of Omo-hyoid	H.G. To Hyo-glossus
A.C. Ansa Cervicis	S.G. To Stylo-glossus

posterior belly of the digastric. It passes forwards and downwards, forming an acute angle with the parent trunk, and it disappears beneath the posterior border of the thyro-hyoid muscle, immediately after which it enters its deep surface.

Carotid Sheath.—The carotid sheath, as stated in connection with the deep cervical fascia, is derived from the posterior lamina of the sheath of the sterno-cleido-mastoid muscle, and is intimately connected anteriorly with the prevertebral process, and posteriorly with the pretracheal process, of the deep cervical fascia. The interior of the sheath is divided into three compartments—outer,

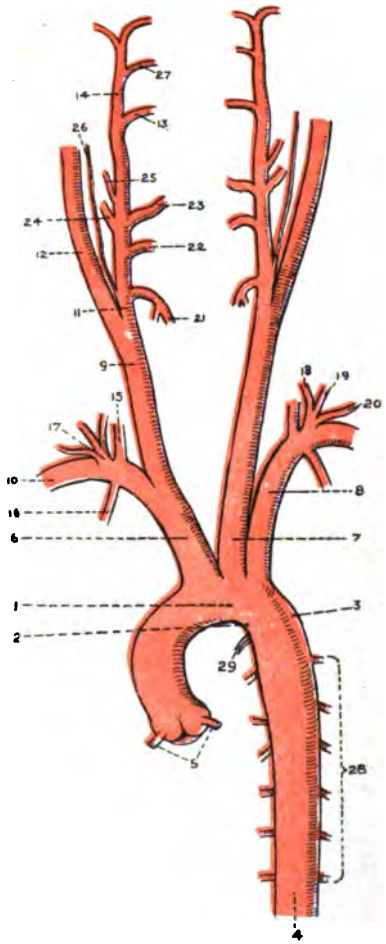


FIG. 435.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Internal Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyroid Axis
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Aortic Intercostals
29. Lig. Ductûs Arteriosi

inner, and posterior, the latter being mesially placed. The outer and inner compartments are separated from each other by a mesial septum, the *inner compartment* containing the common carotid artery and, it may be, the descendens cervicis nerve, and the *outer compartment* the internal jugular vein. The *posterior compartment* is situated within the back part of the septum, and contains the pneumogastric nerve. The descendens cervicis nerve may lie upon the sheath, or within it, and the gangliated cord of the sympathetic descends behind, and in intimate relation with, it.

Common Carotid Arteries.—The *right* common carotid artery arises from the innominate artery behind the upper border of the right sterno-clavicular joint, and the *left* common carotid artery arises from the upper surface of the arch of the aorta, in close proximity to the origin of the innominate artery. The vessel of the right side is therefore entirely cervical, whilst that of the left side is partly thoracic and partly cervical.

The thoracic part of the left common carotid artery has already been described in connection with the thorax (see p. 904).

In the neck the common carotid artery of each side extends from the back of the corresponding sterno-clavicular joint to the level of the upper border of the thyroid cartilage of the larynx, which corresponds to the disc between the bodies of the third and fourth cervical vertebræ. At this level the vessel divides into the external and internal carotid arteries. The place of bifurcation is sometimes opposite the body of the hyoid bone, and, more rarely, on a level with the cricoid cartilage of the larynx. The vessel is about 3¾ inches long, and its course is upwards and outwards in the direction of a line drawn from the sterno-clavicular joint to a point midway between the angle of the inferior maxilla and the mastoid process of the temporal bone. This line, as high as the level of the upper border of the thyroid cartilage, represents the course of the common carotid artery. At the root of the neck the two common carotid arteries are not very far apart, and the trachea lies in the intervening space. As the two vessels ascend they become more divergent, on account of the projection of the lateral lobes of the thyroid body and the thyroid cartilage.

The artery, along with the internal jugular vein and pneumogastric nerve, and, it may be, the descendens cervicis nerve, is contained within the carotid sheath, already described. Opposite the cricoid cartilage it is crossed by the anterior belly of the omo-hyoid muscle. Below this level it lies deeply in the region of the muscular triangle, being under cover of the sterno-hyoid and sterno-thyroid muscles, in addition to the platysma myoides and the anterior border of the sterno-cleido-mastoid. Above this level it is situated in the carotid triangle, being here more superficially placed, its only muscular coverings being the platysma myoides and the anterior border of the sterno-cleido-mastoid.

Relations—*Anterior.*—The skin ; superficial fascia and platysma

myoides; superficial layer of the deep cervical fascia; anterior border of the sterno-cleido-mastoid; sterno-hyoid; sterno-thyroid; anterior belly of the omo-hyoid; and the anterior wall of the carotid sheath. Three veins cross the artery from without inwards, as follows: the anterior jugular vein crosses it immediately above the clavicle, superficial to the sterno-hyoid and sterno-thyroid muscles; the middle thyroid vein crosses it just below the level of the cricoid

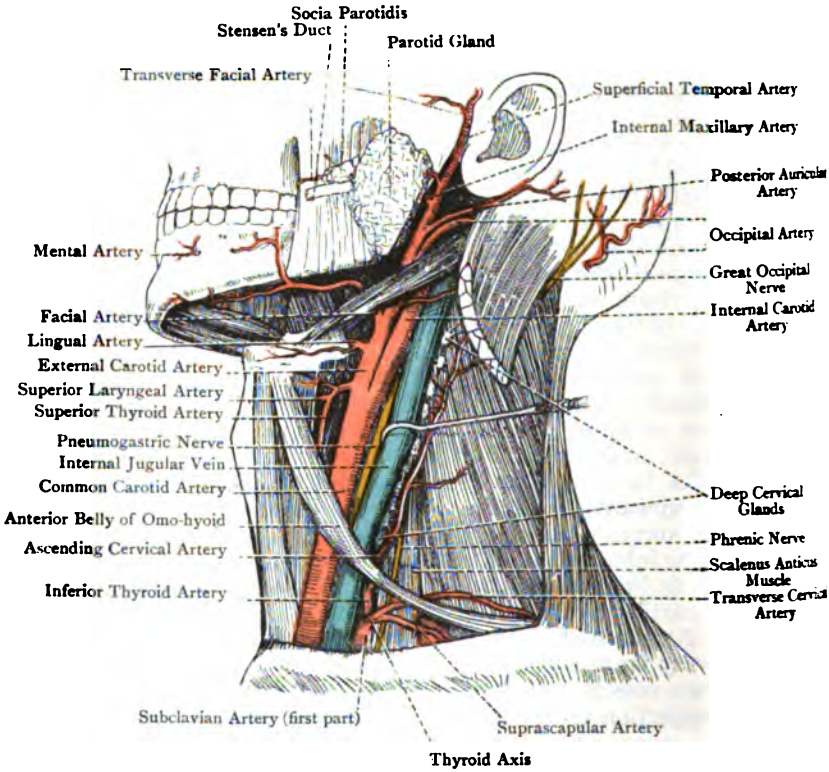


FIG. 436.—DEEP DISSECTION OF THE LEFT SIDE OF THE NECK (AFTER SPALTEHOLZ).

cartilage; and the superior thyroid vein crosses it near its bifurcation. The sterno-cleido-mastoid branch of the superior thyroid artery, which is of small size, passes obliquely downwards and outwards over the carotid sheath in the carotid triangle. The descendens cervicis nerve descends upon, or it may be within, the carotid sheath, lying directly over the artery, and the ansa cervicis (hypoglossi) lies upon the sheath.

Posterior.—The posterior wall of the carotid sheath; the cervical

transverse processes as high as the level of the fourth ; the longus colli, scalenus anticus, and part of the rectus capitis anticus major, muscles ; the gangliated cord of the sympathetic, which is intimately related to the posterior wall of the carotid sheath ; the recurrent laryngeal nerve ; and the inferior thyroid artery, both of which latter structures pass inwards and upwards behind the lower part of the sheath. The carotid body lies behind the vessel close to its bifurcation.

External.—The internal jugular vein and the pneumogastric nerve, the latter lying between the artery and the vein, on a plane posterior to both. At the lower part of the neck, on the right side, the internal jugular vein diverges from the common carotid artery, so as to leave a slight interval in which the right pneumogastric nerve appears as it is about to pass over the first part of the right subclavian artery. On the left side, however, the internal jugular vein is very closely related to the common carotid artery, and more or less overlaps it.

Internal.—From below upwards (1) the trachea and œsophagus, with the recurrent laryngeal nerve and the inferior thyroid artery lying in the intervening groove ; (2) the lateral lobe of the thyroid body, upon which the vessel impresses a groove, and by which it may be slightly overlapped ; and (3) the larynx and pharynx.

The common carotid artery, as a rule, gives off no branch. The superior thyroid artery, however, may arise from it superiorly, and in some cases the ascending pharyngeal artery.

Surgery—Compression.—The part of the vessel most favourably situated for compression lies in front of the tubercle of the costal process of the sixth cervical vertebra, this tubercle, known as the *carotid tubercle of Chassaignac*, and being on a level with the cricoid cartilage of the larynx.

Ligation.—The part of the vessel most favourably placed for ligation is situated on a level with the cricoid cartilage, just above the point where it is crossed by the anterior belly of the omo-hyoid muscle. The structures to be avoided in the operation are as follows : (1) the descendens cervicis nerve, upon, or it may be within, the sheath ; (2) the internal jugular vein and pneumogastric nerve, both of which are within the sheath, and upon the outer side of the artery ; and (3) the gangliated cord of the sympathetic, which lies behind, and in close contact with, the sheath. The small sterno-cleido-mastoid artery will probably be cut, as it passes obliquely downwards and outwards over the sheath in the carotid triangle. Ligation of the artery *below* the level of the cricoid cartilage is attended with difficulty, the vessel being here covered by the sterno-hyoid and sterno-thyroid muscles, in addition to the platysma myoides and sterno-cleido-mastoid. On the left side the internal jugular vein would constitute an additional difficulty.

Collateral Circulation after Ligation.—(1) Cross anastomoses take

posterior triangle, and this process is attached to the back of the inner end of the clavicle and the first rib, which explains the almost horizontal position occupied by the posterior belly.

The anterior belly proceeds from the intervening tendon, and passes upwards and slightly inwards to the body of the hyoid bone. As it emerges from beneath the anterior border of the sterno-cleido-mastoid muscle the anterior belly crosses the carotid sheath on a level with the narrow anterior part of the cricoid cartilage, and in the anterior triangle of the neck it forms the separation between the muscular (inferior carotid) and carotid (superior carotid) triangles.

Sterno-hyoid—*Origin.*—(1) The posterior surface of the manubrium sterni at its upper and outer part; (2) the posterior sterno-clavicular ligament; and, it may be, (3) the posterior surface of the clavicle at its inner end.

Insertion.—The inner two-thirds of the lower border of the body of the hyoid bone, extending from the middle line to the insertion of the anterior belly of the omo-hyoid.

Nerve-supply.—The ansa cervicis (ansa hypoglossi).

The muscle is flat and ribbon-like, and rests upon the sterno-thyroid and thyro-hyoid.

Sterno-thyroid—*Origin.*—(1) The posterior surface of the manubrium sterni at its upper and outer part, below the origin of the sterno-hyoid; and (2) the posterior surface of the first costal cartilage.

Insertion.—The oblique line on the outer surface of the ala of the thyroid cartilage.

Nerve-supply.—The ansa cervicis (ansa hypoglossi).

The muscle is broader, but shorter, than the sterno-hyoid, underneath which it lies. Within the thorax the right muscle lies in front of the innominate artery, and the left in front of the left common carotid artery and left innominate vein. In the neck each muscle rests upon the carotid sheath and the corresponding lateral lobe of the thyroid body.

The sterno-hyoid muscles as they emerge from the thorax are separated by an interval, in which situation the sterno-thyroid muscles lie in close contact. As the muscles ascend, the sterno-hyoids converge, but the sterno-thyroids diverge.

Thyro-hyoid—*Origin.*—The oblique line on the outer surface of the ala of the thyroid cartilage.

Insertion.—(1) The outer half of the lower border of the body of the hyoid bone; and (2) the basal half of the great cornu of that bone.

Nerve-supply.—The thyro-hyoid nerve, which is a special branch of the hypoglossal. The nerve enters the deep surface of the muscle close to its posterior border.

The muscle is quadrilateral. Its superficial surface supports the anterior belly of the omo-hyoid and the sterno-hyoid muscles, and its deep surface is related to the ala of the thyroid cartilage,

the thyro-hyoid membrane, the internal branch of the superior laryngeal nerve, and the superior laryngeal artery.

The nerves which supply the infrahyoid group of muscles are regarded as being of spinal origin.

Action of the Infrahyoid Muscles—**Omo-hyoid.**—(1) To depress the hyoid bone ; and (2) to render tense the deep cervical fascia in the lower part of the neck.

Sterno-hyoid.—To depress the hyoid bone.

Sterno-thyroid.—To depress the thyroid cartilage.

Thyro-hyoid.—(1) To depress the hyoid bone ; and (2) to elevate the thyroid cartilage, as in the production of high notes, or in deglutition.

Structures in the Median Line of the Neck.—The median line of the neck is divisible into two regions, suprahyoid and infrahyoid.

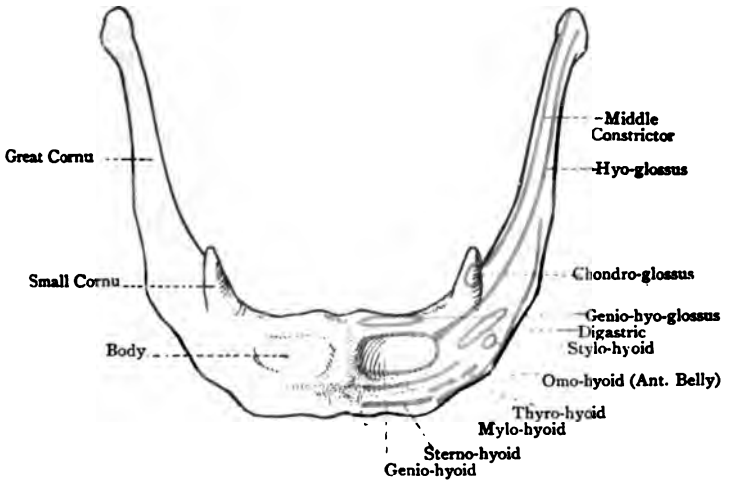


FIG. 431.—THE HYOID BONE, SHOWING ITS MUSCULAR ATTACHMENTS.

Suprahyoid Region.—The innermost fibres of the two platysma myoides muscles decussate at the median line for a short distance below the chin. On either side of the median line, under cover of the platysma myoides, is the anterior belly of the digastric muscle. The anterior bellies of opposite sides are near each other at the chin, but, as they descend with an inclination outwards, they diverge from each other and leave between them a triangular interval, called the **submental triangle.** The base of this triangle is formed by the body of the hyoid bone, and each lateral boundary is constructed by the anterior belly of the digastric, the apex being placed at the chin. The area of the triangle is occupied by the anterior portions of the mylo-hyoid muscles, which meet at the median line in a tendinous raphé, and superficial to these muscles

bedded in the substance of the parotid gland, where it is crossed from behind forwards by the facial nerve.

Relations—*Anterior.*—The skin; superficial fascia; platysma myoides; deep fascia; anterior border of the sterno-cleido-mastoid; the lingual and common facial veins; the hypoglossal nerve (all the foregoing being anterior relations, whilst the artery lies in the superior carotid triangle); the posterior belly of the digastric and stylo-hyoid muscles; the greater part of the parotid gland; the temporo-maxillary vein; and the facial nerve. *Posterior.*—The

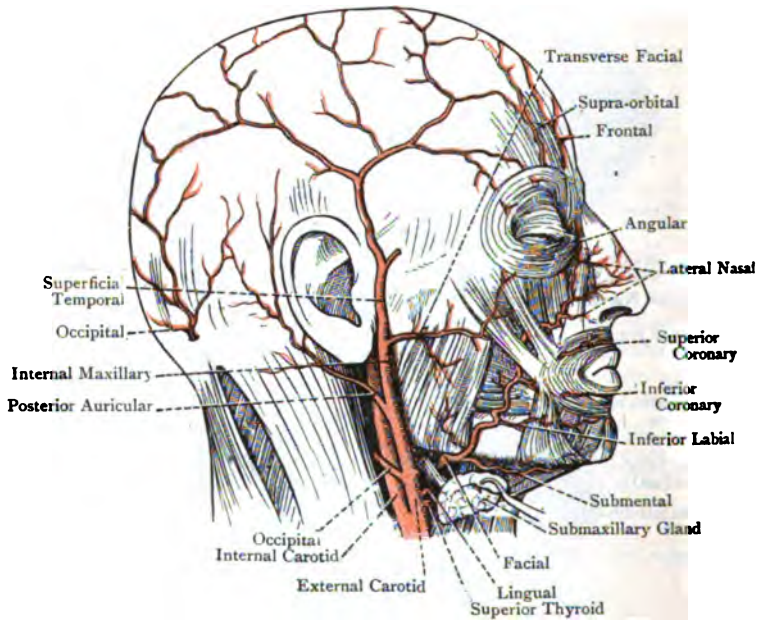


FIG. 438.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

chief posterior relations are as follows: (1) the stylo-pharyngeus muscle, glosso-pharyngeal nerve, and styloid process of the temporal bone, all of which intervene between the vessel and the internal carotid (the latter now lying behind the external carotid); and (2) a small portion of the parotid gland. *External.*—The internal carotid artery for a short distance. *Internal.*—The pharynx and hyoid bone; the superior laryngeal nerve; a portion of the parotid gland; and the posterior border of the ramus of the inferior maxilla.

The external carotid artery has no vein in the sense of a companion vessel, but the temporo-maxillary vein descends in front of

it, in the parotid gland, to near the angle of the inferior maxilla, beyond which point the artery has no vein.

The course of the vessel may be indicated by a line drawn from the side of the cricoid cartilage of the larynx to the tragus of the auricle.

Development.—The external carotid artery is the persistent part of the ventral aorta above the level of the third arterial arch.

Branches.—These are arranged in four sets, anterior, posterior, ascending, and terminal, and are as follows :

Anterior.	Posterior.	Ascending.	Terminal.
Superior thyroid.	Occipital.	Ascending	Superficial temporal.
Lingual.	Posterior auricular.	pharyngeal.	Internal maxillary.
Facial.			

Superior Thyroid Artery.—This vessel arises in the carotid triangle from the front part of the external carotid close to its commencement. It takes an arched course forwards and downwards, passing under cover of the depressor muscles of the hyoid bone. On reaching the apex of the lateral lobe of the thyroid body it breaks up into its terminal branches, which enter the lobe on its superficial aspect, and anastomose freely, within it, with branches of the inferior thyroid artery, and, in the isthmus, with its fellow of the opposite side.

Branches.—These are as follows :

Infrahyoid.	Crico-thyroid.
Sterno-cleido-mastoid.	Glandular.
Superior laryngeal.	Muscular.

The *infrahyoid artery* passes inwards on the thyro-hyoid membrane, beneath the thyro-hyoid muscle, and close to the lower border of the hyoid bone. It anastomoses at the middle line with its fellow of the opposite side, and with the suprahyoid branch of the lingual artery of the same side. The *sterno-cleido-mastoid artery* passes obliquely downwards and outwards, over the upper part of the carotid sheath, to enter the deep surface of the muscle from which it takes its name. It is liable to be cut in ligation of the common carotid artery. The *superior laryngeal artery* accompanies the internal laryngeal nerve, and passing beneath the outer border of the thyro-hyoid muscle, it pierces the thyro-hyoid membrane, to be distributed to the interior of the larynx. The *crico-thyroid artery* passes transversely inwards upon the crico-thyroid membrane, and anastomoses with its fellow of the opposite side to form the *crico-thyroid arch.* This arch is situated midway between the cricoid and thyroid cartilages, but, notwithstanding this position, it may be in danger in the operation of laryngotomy. The *glandular branches* are distributed to the lateral lobe of the thyroid body. They anastomose freely with

branches of the inferior thyroid of the same side, and with branches of its fellow of the opposite side. One very constant branch, known as the *artery of the isthmus*, courses along the upper border of the isthmus, and anastomoses with its fellow of the opposite side. The *muscular branches* are distributed to the depressor muscles of the hyoid bone.

The **superior thyroid vein** issues from the upper part of the lateral lobe of the thyroid body, and crosses in front of the common carotid artery, near its bifurcation, to open into the internal jugular vein. Its tributaries for the most part correspond to the branches of the artery, amongst these being the crico-thyroid and superior laryngeal veins.

Lingual Artery.—The lingual artery arises from the front part of the external carotid, a little above the origin of the superior thyroid. and opposite the great cornu of the hyoid bone. From its com-

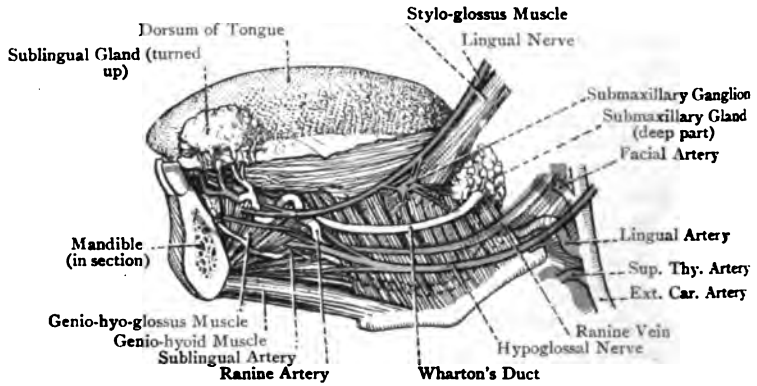


FIG. 439.—DEEP DISSECTION OF THE LEFT SUBMAXILLARY REGION.

plicated course it is convenient to divide the artery into three parts.

First Part.—The first part of the vessel ascends for a little, and then, bending sharply, descends to the upper border of the hyoid bone, passing beneath the posterior belly of the digastric and stylo-hyoid muscles. So far the vessel lies in the carotid triangle and the bend which it describes is crossed by the hypoglossal nerve. It is for the most part comparatively superficial.

Second Part.—The second part passes horizontally forwards along the upper border of the hyoid bone beneath the hyo-glossus muscle, the hypoglossal nerve and ranine vein being superficial to that muscle. At the anterior border of the hyo-glossus it enters upon the third part of its course. The second part lies deeply in **Lesser's triangle,** the boundaries of which are as follows : the *base,* which is directed upwards, is formed by a portion of the hypo-

glossal nerve; the *two sides* are formed by the tendon of the digastric, which is here disposed in the form of a V; and the *floor* is formed by the hyo-glossus muscle. The artery lies under cover of that muscle, and rests upon the middle constrictor of the pharynx.

Third Part.—Near the anterior border of the hyo-glossus muscle the lingual artery describes another sharp bend in an upward direction, and ascends almost vertically to the under surface of the tongue, resting upon the genio-hyo-glossus, and being under cover of the anterior border of the hyo-glossus. Having reached the tongue, the artery passes forwards on its under surface in a tortuous manner, under the name of the ranine artery.

Branches.—These are as follows:

1. Suprahyoid.
2. Dorsalis linguæ.
3. Sublingual.
4. Ranine.

The *suprahyoid artery* arises from the lingual at the posterior border of the hyo-glossus, and passes inwards along the upper border of the hyoid bone to supply the adjacent structures. At the median line it anastomoses with its fellow of the opposite side, and with the infrahyoid branch of the superior thyroid of the same side.

The *dorsalis linguæ artery* arises under cover of the hyo-glossus muscle, which it pierces, and so reaches the posterior third of the dorsum of the tongue. It is distributed to the mucous membrane and substance of the tongue, the tonsil, and the soft palate, and it anastomoses with its fellow of the opposite side.

The *sublingual artery* arises close to the anterior border of the hyo-glossus muscle. It supplies the sublingual gland, the adjacent muscles, and the mucous membrane of the floor of the mouth. One of the lateral branches anastomoses at the median line with a corresponding branch of the opposite artery, and another of them is known as the *artery of the frenum linguæ.*

The *ranine artery* is the terminal part of the lingual. It passes forwards on the under surface of the tongue, lying immediately external to the insertion of the genio-hyo-glossus, between it and the inferior lingualis. It is more or less embedded in the substance of the tongue, and its course is tortuous in adaptation to the mobility of the organ to which it is so intimately related. Towards the tip of the tongue the vessel is very superficially placed, lying close by the side of the frenum linguæ, and it anastomoses with its fellow of the opposite side near the tip. Elsewhere the cross anastomoses are unimportant. The ranine artery furnishes branches freely to the substance of the tongue. Its close relation to the frenum linguæ is to be carefully noted in connection with the operation for relief of tongue-tied children.

The **lingual veins** are as follows: (1) the *ranine vein*, which is of large size, commences under the tip of the tongue, and passes

backwards, in company with the hypoglossal nerve, over the hyo-glossus muscle, receiving tributaries from the surrounding structures; (2) two *venæ comites* accompanying the lingual artery; and (3) the *dorsal lingual veins*, which originate in a plexus beneath the mucous membrane over the posterior third of the organ. These three sets of veins may join into a common trunk, called the **lingual vein**, which opens into the internal jugular vein, or they may terminate independently in that vein.

Facial Artery.—The facial artery arises from the front part of the external carotid in the carotid triangle, immediately above the lingual artery, or sometimes in common with that vessel. It passes upwards and forwards, beneath the hypoglossal nerve and the posterior belly of the digastric and stylo-hyoid muscles, into the submaxillary triangle. Thereafter it becomes embedded in a groove on the upper and back part of the submaxillary gland, its course in this situation being horizontally forwards. Having emerged from this groove, it describes a sharp bend and mounts upwards over the base of the inferior maxilla, in front of the masseter muscle. The vessel then enters upon the facial part of its course, for a description of which see p. 1102.

Branches.—Four branches arise from the cervical part of the facial artery, as follows:

1. Inferior palatine.
2. Tonsillar.
3. Glandular.
4. Submental.

The *inferior palatine artery* passes upwards between the stylo-glossus and stylo-pharyngeus muscles, and then over the upper border of the superior constrictor of the pharynx, along with the levator palati muscle. It is distributed to the soft palate, tonsil, and Eustachian tube. The *tonsillar artery* passes upwards between the stylo-glossus and internal pterygoid muscles, and, after piercing the superior constrictor muscle, it is distributed to the tonsil and the posterior part of the side of the tongue. The *glandular branches* are distributed to the submaxillary gland. The *submental artery* arises from the facial as it is about to mount over the base of the inferior maxilla, and it passes forwards upon the mylo-hyoid muscle. It gives branches to the submaxillary gland and mylo-hyoid muscle, some of the branches piercing that muscle to reach the sublingual gland and anastomose with the sublingual artery. Near the symphysis it ascends over the base of the inferior maxilla, and supplies the muscles of the lower lip and the integument of the chin. The terminal part of the vessel anastomoses with the mental and inferior labial arteries, and with its fellow of the opposite side.

The cervical part of the **facial vein** passes downwards and backwards superficial to the submaxillary gland. Having received tributaries corresponding to the branches of the cervical part of the artery, it unites with the anterior division of the temporo-maxillary

vein to form the **common facial vein,** which opens into the internal jugular opposite the body of the hyoid bone.

Occipital Artery.—The occipital artery arises from the posterior aspect of the external carotid opposite the facial artery. It passes at first upwards and slightly backwards beneath the posterior belly of the digastric and stylo-hyoid muscles, and the hypoglossal nerve, having hooked round it, passes forwards over it. Having reached the level of the interval between the transverse process of the atlas and the mastoid process, the artery changes its course, and passes backwards to occupy the occipital groove on the inner aspect of the mastoid process. In this backward course it crosses the internal carotid artery, internal jugular vein, and pneumogastric, spinal accessory, and hypoglossal nerves. As it lies in the occipital groove the vessel is very deeply placed, being covered by the following structures : (1) the origin of the posterior belly of the digastric ; (2) the trachelo-mastoid ; (3) the splenius capitis ; and (4) the sterno-cleido-mastoid. After escaping from beneath the splenius capitis, the vessel takes an upward course over the complexus to the occipital region, where it ramifies in a tortuous manner, along with the branches of the great occipital nerve.

Branches.—These are as follows : muscular ; meningeal ; mastoid ; ramus princeps cervicis ; and terminal.

The *muscular branches* are distributed to the adjacent muscles. One of them crosses the hypoglossal nerve and enters the deep surface of the sterno-cleido-mastoid muscle, in company with the spinal portion of the spinal accessory nerve. The *meningeal branch* accompanies the internal jugular vein, and enters the cranial cavity through the jugular foramen to supply the dura mater of the posterior fossa. The *mastoid branch* passes through the arterial fissure in the mastoid process, and supplies the adjacent dura mater. The ramus princeps cervicis and the terminal branches have been already described (see p. 987).

The occipital veins will be found described on p. 988.

Posterior Auricular Artery.—This vessel arises from the posterior aspect of the external carotid a little above the origin of the occipital artery, and above the posterior belly of the digastric. It passes upwards and slightly backwards under cover of the lower part of the parotid gland, and over the styloid process of the temporal bone, being crossed by the facial nerve. Having reached the groove between the back of the auricle and the mastoid process, where it meets the posterior auricular nerve, it divides into two branches, auricular and mastoid.

Branches.—These are as follows : muscular ; glandular ; stylo-mastoid ; auricular ; and mastoid.

The *muscular branches* supply the adjacent muscles. The *glandular branches* are distributed to the lower part of the parotid gland. The *stylo-mastoid artery* enters the aqueduct of Fallopius through the stylo-mastoid foramen. It is distributed to the tympanic cavity and the mastoid cells, and anastomoses with

the tympanic branch of the first part of the internal maxillary artery. With this latter branch it forms a ring at the circumference of the membrana tympani on its inner aspect. Within the aqueduct of Fallopius the stylo-mastoid artery anastomoses with the petrosal branch of the middle meningeal artery, which branch enters the aqueduct through the hiatus Fallopii. The *auricular branch* passes upwards beneath the retrahens auriculam muscle, and furnishes branches to the inner aspect of the auricle, some of which reach the outer surface by piercing the cartilage and by turning round its margin. The auricular branch anastomoses with the posterior division of the superficial temporal artery. The *mastoid branch* passes backwards over the mastoid process to the occipital region, and anastomoses with the occipital artery.

The **posterior auricular vein,** of fairly large size, unites with the posterior division of the temporo-maxillary vein near the angle of the inferior maxilla, and by this union the external jugular vein is formed.

Ascending Pharyngeal Artery.—This long, slender vessel arises from the deep surface of the external carotid near its commencement. It passes vertically upwards towards the base of the skull, lying very deeply upon the rectus capitis anticus major muscle, and between the internal carotid artery and the pharynx.

Branches.—These are as follows :

1. Pharyngeal.
2. Palatine.
3. Prevertebral.
4. Tympanic.
5. Meningeal.

The *pharyngeal branches* are distributed to the pharynx. The *palatine branch* passes over the superior constrictor muscle of the pharynx, and is distributed to the soft palate, Eustachian tube, and tonsil. The *prevertebral branches* supply the prevertebral muscles. The *tympanic branch* passes with the tympanic branch of the glosso-pharyngeal nerve through the tympanic canaliculus in the petrous part of the temporal bone, and so reaches the tympanum, to the inner wall of which it is distributed. The *meningeal arteries* are the terminal branches of the ascending pharyngeal, and are three in number. One passes through the foramen lacerum medium, a second through the jugular foramen, and a third through the anterior condylar foramen, to be distributed to the dura mater in the vicinity of these foramina.

No specially-named vein accompanies the ascending pharyngeal artery.

For the superficial temporal and internal maxillary branches of the external carotid artery, see pp. 995 and 1124.

The internal carotid artery will be found described on p. 1144.

Thyroid Body.—The thyroid body is situated on either side of the upper part of the trachea and the larynx, and a small portion of

it lies in front of the upper part of the trachea. Its size is subject to much variation; its weight is rather more than 1 ounce; and it is larger in the female than in the male. It consists of two lateral lobes and an isthmus.

Each **lateral lobe** is conical, the rounded base being directed downwards, and it measures about 2 inches in length. It extends from the inferior cornu and adjacent portion of the ala of the thyroid cartilage to about the level of the fifth ring of the trachea. Its *superficial surface*, which looks forwards and outwards, is somewhat convex, and is covered by the sterno-thyroid, sterno-hyoid, and anterior belly of the omo-hyoid muscles. It is also overlapped by the anterior border of the sterno-cleido-mastoid. Its *deep surface* is concave in adaptation to the trachea and larynx. The *anterior border* is thin, and towards its lower part is connected with that of the opposite lateral lobe by means of the isthmus. The *posterior border* is thick, and is in contact with the pharynx and œsophagus. The lateral lobe slightly overlaps the common carotid artery, enclosed in the carotid sheath, and is frequently grooved by that vessel. Inferiorly it overlaps the recurrent laryngeal nerve and inferior thyroid artery. The apex of the lateral lobe rests upon the inferior constrictor muscle of the pharynx, and the superior thyroid artery enters it superficially.

The **isthmus** is inconstant as regards size and position. Its depth ranges from ¼ to 1 inch, and its breadth is about ½ inch. It connects the lower parts of the anterior borders of the lateral lobes, but does not reach quite so low as their bases. It lies in front of the trachea, usually upon the second and third rings, sometimes upon the upper three rings, or it may be the second, third, and fourth rings. It fits closely to the rings upon which it rests. Along its upper border there is a branch of the superior thyroid artery, known as the *artery of the isthmus*, which anastomoses with its fellow of the opposite side. From its lower border several veins issue, which take part in the inferior thyroid plexus of veins in front of the trachea.

In some cases an additional lobe is present, called the **pyramidal,** or **middle, lobe.** It takes the form of a long pyramid which is attached by its base to the upper border of the isthmus, usually at its junction with the left lateral lobe. Its apex is attached to the body of the hyoid bone by a fibrous band, which sometimes contains muscular fibres, known as the *levator glandulæ thyroideæ muscle.*

The thyroid body is invested by a fibrous sheath which is derived from the pretracheal lamina of the deep cervical fascia.

When a portion or portions of the pyramidal lobe, or of a lateral lobe, become detached, the isolated masses are known as **accessory thyroids.**

Blood-supply—Arteries.—The thyroid body is characterized by great vascularity. The arteries on either side are (1) the superior thyroid, which is a branch of the external carotid, and (2) the

inferior thyroid, which is a branch of the thyroid axis of the first part of the subclavian. Occasionally there is a third thyroid artery, called the *arteria thyroidea ima*, which is derived from the innominate artery, or from the arch of the aorta, and is distributed to the isthmus, its position being in front of the trachea at the median line, or close to it.

The **veins** are three in number on either side, namely, superior,

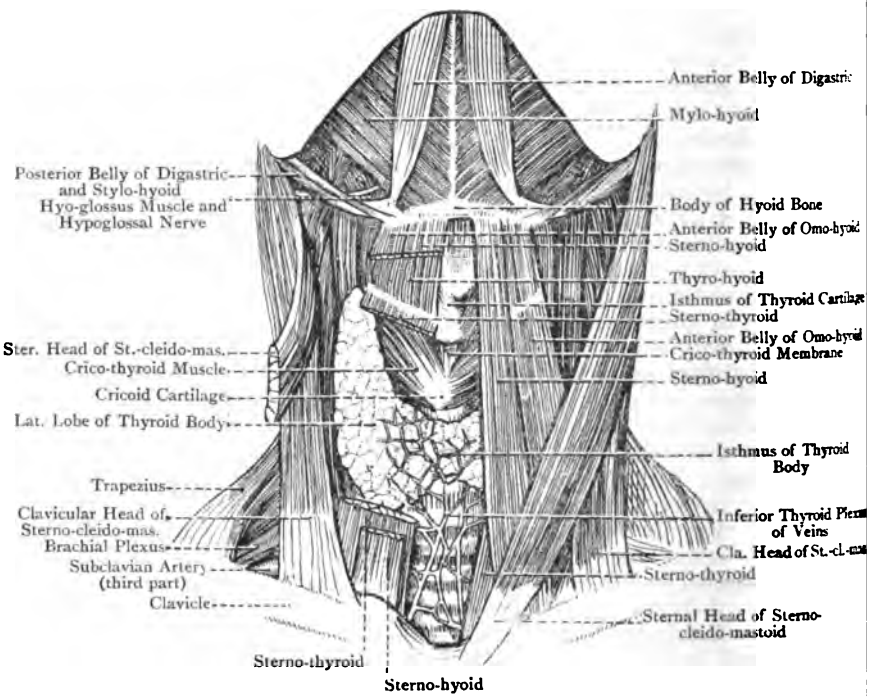


FIG. 440.—DISSECTION OF THE FRONT OF THE NECK.

(The area bounded on either side by the Anterior Belly of the Digastric and below by the body of the Hyoid Bone is the Submental Triangle.)

middle, and inferior. The **superior** and **middle thyroid veins** open into the internal jugular. The **inferior thyroid veins,** right and left, issue from a plexus of veins in front of the trachea below the isthmus. The *left* vein opens into the left innominate vein, whilst the right has a variable mode of termination. It may open into the left innominate vein, or into the angle of junction of the right and left innominate veins, or into the lower part of the right innominate vein.

Nerves.—These are derived from the sympathetic plexuses which accompany the superior and inferior thyroid arteries.

Structure. — The thyroid body has an external capsule of dense connective tissue which sends trabeculæ into the interior, thereby dividing it into irregular lobules. These **lobules** are composed of groups of **closed vesicles,** which are connected together by areolar tissue. The vesicles are oval or spherical, and each is lined with a single layer of columnar, or cubical, epithelium. They contain a yellowish, viscid, albuminous fluid called *colloid,* and are surrounded by networks of capillary bloodvessels.

Development.—The thyroid body is developed from three tubular diverticula —median and two lateral. The **median diverticulum,** which is known as the *ductus thyro-glossus,* is derived from the pharyngeal hypoblast opposite the second visceral clefts, between the tuberculum impar (which gives rise to the anterior two-thirds of the tongue), and the root or pharyngeal part of the tongue. The upper part of this diverticulum soon loses its connection with the pharyngeal hypoblast, and its upper extremity persists as the *foramen cæcum* of the tongue. The lower part gives rise to the **isthmus** of the thyroid body, and the intervening portion disappears. The part of this diverticulum, however, which is adjacent to the isthmus frequently undergoes development, and so gives rise to the **pyramidal,** or **middle, lobe.**

Each **lateral diverticulum** is derived from the fourth visceral cleft of the corresponding side, and it gives rise to the lateral lobe, which joins the isthmus on either side.

The three diverticula become transformed into cylinders of cells, which branch and anastomose with one another. The cylinders then become hollow, and are broken up into the vesicles which contain the colloid.

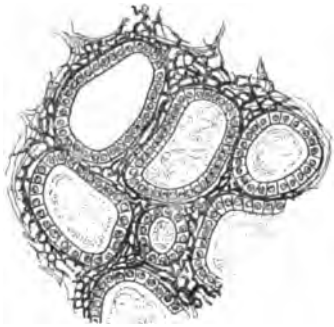


FIG. 441. — SECTION OF THE THYROID BODY, SHOWING THE VESICLES AND THEIR EPITHELIAL LINING.

(The Colloid is indicated.)

Parathyroids.—These are two in number on either side. One is related to the posterior border of the lateral lobe, and the other to its mesial border. Each is about ¼ inch in diameter, and consists of a collection of epithelial cells pervaded by bloodvessels. They are probably developed in connection with the thymus body.

The Trachea and Œsophagus.

Trachea.—The trachea extends from the cricoid cartilage of the larynx to about the level of the disc between the bodies of the fourth and fifth thoracic vertebræ, where it divides into the two bronchi, right and left. Its average length is about 4½ inches, and its width about 1 inch. Anteriorly and laterally it is cylindrical and firm, but posteriorly it is flattened and membranous, so that it does not press upon the œsophagus, over which it lies. It occupies a mesial position, and its direction is downwards with an inclination backwards. It is divisible into two parts, cervical and thoracic.

For the trachea in the thorax, see p. 945.

The **cervical part of the trachea** extends from the cricoid cartilage to the level of the upper border of the manubrium sterni, and it measures about 2½ inches in length. It is freely movable, and is surrounded by areolar tissue, which contains many elastic fibres, and is somewhat loosely arranged.

Relations—*Anterior.*—The isthmus of the thyroid body lies directly upon the second and third rings as a rule, the first ring usually lying exposed between its upper border and the cricoid

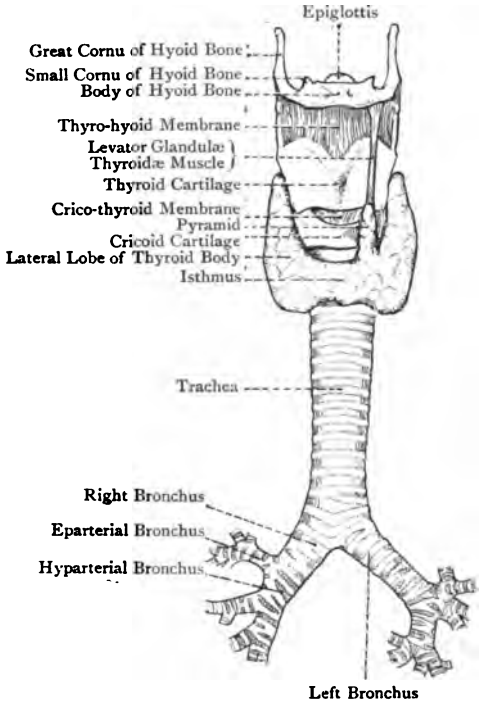


FIG. 442.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (ANTERIOR VIEW).

cartilage. Superficial to the first ring, on the left of the median line, there may be the lower part of the pyramidal, or middle, lobe of the thyroid body. Below the isthmus is the inferior thyoid plexus of veins, from which the right and left inferior thyroid veins pass downwards, one on either side of the median line. The arteria thyroidea ima may ascend to the isthmus of the thyroid body, lying in front of the trachea at the median line, or slightly to the right of it. The anterior jugular veins, right and left, are anterior to it, and just above the manubrium sterni it is

crossed by the communicating branch which passes between these two veins. In children under two years of age the cervical portion of the thymus body forms an important anterior relation. Close to the upper border of the manubrium sterni the innominate artery may encroach slightly upon it. The pretracheal lamina of the deep cervical fascia forms an anterior relation, as well as the superficial layer of that fascia, which layer is here arranged in two divisions enclosing the space of Burns and the anterior jugular veins, along with one or two lymphatic glands. The sterno-hyoid and sterno-

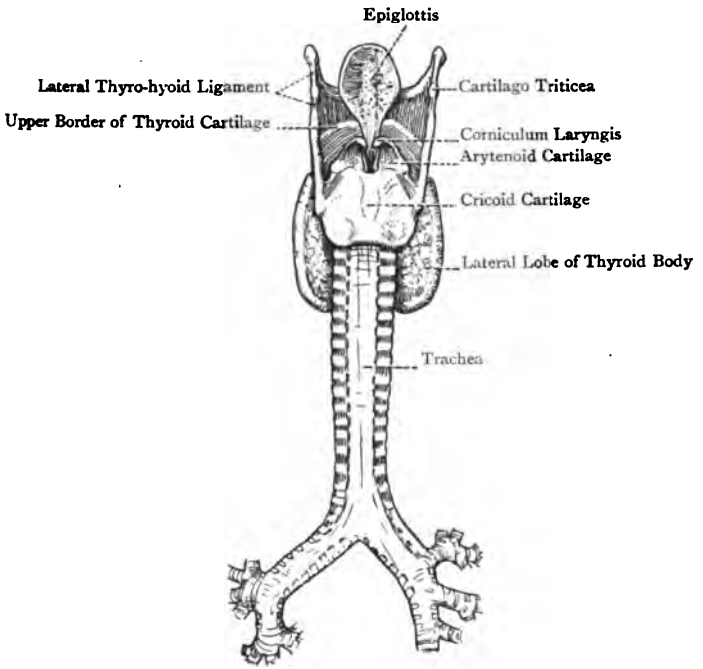


FIG. 443.—THE EPIGLOTTIS, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (POSTERIOR VIEW).

thyroid muscles cover it in the following manner: the sterno-hyoid muscles are separated by an interval below, but they come nearly into contact above; and the sterno-thyroid muscles are in contact below, but diverge above. Between the muscles of opposite sides there is a very narrow interval, along which the trachea is free from muscular covering, the pretracheal fascia being here of some strength.

Lateral.—The trachea is closely embraced on either side by the lateral lobe of the thyroid body as low as about the level of the fifth

ring, and external to this is the carotid sheath with its contents, the common carotid artery being nearest the lateral lobe.

Posterior.—The trachea rests upon the œsophagus, which projects a little to its left side towards the root of the neck. Between the two there is a groove, in which the recurrent laryngeal nerve and inferior laryngeal artery ascend.

For a reference to the high and low operations of tracheotomy, see p. 1032.

Blood-supply.—The **arteries** of the cervical part of the trachea are

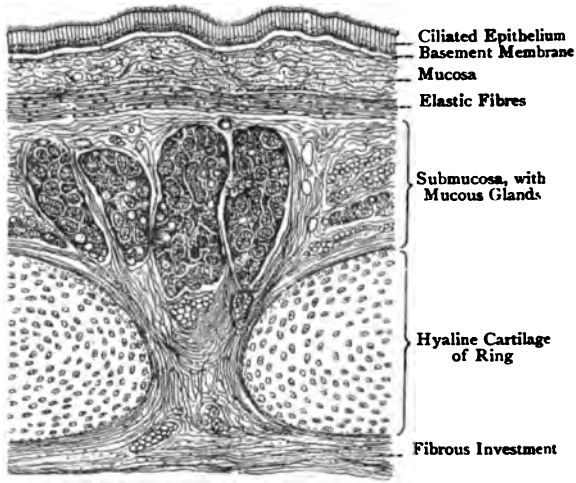


FIG. 444.—LONGITUDINAL SECTION OF THE TRACHEA.

derived from the inferior thyroid of each side, which is a branch of the thyroid axis.

The **veins** terminate in the inferior thyroid plexus and inferior thyroid veins.

The **lymphatics** pass to the lower group of deep cervical glands.

Nerve-supply.—The nerves are derived from the pneumogastric, recurrent laryngeal, and sympathetic.

Structure.—The trachea is composed of about twenty so-called rings of hyaline cartilage, which are incomplete posteriorly. They serve to keep the tube permanently open for the transmission of air, and are embedded in fibrous tissue, which also connects together their contiguous borders. They are shaped thus—C, and each forms rather more than two-thirds of a circle, being flat externally, and convex internally. The deficient portions of the rings are, as stated, placed posteriorly, and here each ring ends in two round extremities. The intervals between these extremities are bridged over by fibrous tissue, continuous with that which connects the borders of the rings and in which they are embedded. In some cases a ring may terminate in a bifurcated extremity, or it may join one of the adjacent rings. The lowest ring is deep, and its lower border projects backwards so as to form a ridge between the openings of the two bronchi.

In the posterior wall of the trachea, within the **fibrous layer,** there is a continuous layer of **unstriped muscular tissue.** the fibres of which extend transversely between the ends of the rings to which they are attached. In the intervals between the extremities of the rings they are attached to the fibrous coat. These fibres serve to approximate the ends of the rings, and so diminish the calibre of the tube.

The **submucous coat** consists of loosely-arranged areolar tissue, and contains the larger bloodvessels and nerves, together with the mucous glands.

The **mucous coat** consists of areolar and elastic tissues, and a large amount of lymphoid or adenoid tissue. It contains the ramifications of the arteries and nerves, as well as the lymphatics. Superficial to the mucosa there is a well-marked basement membrane which supports the epithelium. The deep portion of the mucosa consists principally of elastic fibres. On the posterior wall these elastic fibres are very numerous, and are arranged in longitudinal bundles which give rise to elevations of the mucosa.

The **epithelium** is of the stratified columnar ciliated variety.

The wall of the trachea contains many **mucous glands.** Some of these are situated in the submucous coat. Others, which are of large size, are situated on the posterior wall, where they are very superficial, many of them, like small grains, lying superficial to the fibrous layer, where they are quite visible. Others are contained within the fibrous layer. The ducts of these glands have to pass through (1) the muscular layer, (2) the elastic layer (part of the mucosa), and (3) the mucosa, upon the surface of which they open by apparent orifices.

Development.—The trachea is developed from the lower part of a median diverticulum from the ventral aspect of the fore-gut superiorly, the upper part of this diverticulum giving rise to the larynx.

Œsophagus.—The œsophagus is that part of the alimentary canal which extends from the pharynx to the stomach. In the neck it commences on a level with the lower border of the cricoid cartilage, and terminates on a level with the upper border of the manubrium sterni. It is compressed from before backwards, and lies between the trachea and the vertebral column covered by the longus colli muscles. At first it occupies the median line, but as it descends it inclines slightly to the left side, so as to be partially visible on the left side of the trachea.

Relations—*Anterior.*—The trachea; the posterior parts of the lateral lobes of the thyroid body; the recurrent laryngeal nerves; and the inferior thyroid arteries. *Posterior.*—The vertebral column and the longus colli muscles, covered by the prevertebral fascia. *Lateral.*—On either side there is the carotid sheath with its contents. The right and left recurrent laryngeal nerves are intimately related to the œsophagus, and ascend on each side in the groove between it and the trachea.

The cervical part of the œsophagus receives its blood-supply from the inferior thyroid arteries, right and left, each of which accompanies the corresponding recurrent laryngeal nerve.

For a description of the œsophagus in the thorax, including its structure and development, see p. 947.

Suprahyoid Region—Muscles—Digastric.—The digastric muscle consists of two bellies, posterior and anterior. *Origin.*—The **posterior belly** arises from the digastric groove on the inner aspect of the mastoid part of the temporal bone; and the **anterior belly**

arises from the digastric impression on the inner surface of the body of the inferior maxilla, close to the base and symphysis.

Insertion.—The two bellies end upon an intervening tendon, about 2 inches long, which is inserted by means of a broad fibrous band into (1) the anterior surface of the body of the hyoid bone at its outer part, and (2) the adjacent portion of the great cornu.

Nerve-supply.—The posterior belly is supplied by the digastric branch of the facial nerve ; and the anterior belly derives its nerve-supply from the mylo-hyoid branch of the inferior dental, which is a branch of the inferior division of the fifth cranial nerve.

The posterior belly is directed downwards and forwards, and the anterior belly downwards and slightly outwards.

Action.—(1) To elevate the hyoid bone, as in the act of deglutition ; and (2) to depress the inferior maxilla.

Relations.—The **posterior belly** is at first deeply placed, being overhung by the mastoid process, and lying under cover of the trachelo-mastoid, splenius capitis, and sterno-cleido-mastoid muscles. It is also overlapped by the lower part of the parotid gland. It crosses the external and internal carotid arteries, internal jugular vein, and hypoglossal nerve. The stylo-hyoid muscle lies above it, and the hypoglossal nerve below it for a short distance. The intervening tendon is embraced by the fibres of the stylo-hyoid muscle. This tendon crosses the hypoglossal nerve, and forms two sides of a triangle, known as the **triangle of Lesser,** the base of which is directed upwards, and is formed by the hypoglossal nerve. In the area of this triangle is a portion of the hyo-glossus muscle, and beneath this part is a portion of the lingual artery. The **anterior belly,** which is shorter than the posterior, is covered by the integument, platysma myoides, and deep cervical fascia. It rests upon the mylo-hyoid muscle, and forms the lateral boundary of the submental triangle. Its inner border is connected with that of its fellow by a fascial expansion.

Stylo-hyoid—*Origin.*—The posterior and outer aspect of the styloid process of the temporal bone near its base.

Insertion.—The anterior surface of the hyoid bone at the junction of the body and great cornu.

Nerve-supply.—The stylo-hyoid branch of the facial nerve, which arises in common with the digastric branch.

The muscle is directed downwards and forwards.

Action.—To draw the hyoid bone upwards and backwards.

The muscle lies close above the posterior belly of the digastric, and, before taking insertion, it usually splits into two bundles, which embrace the intervening tendon of the digastric.

Mylo-hyoid—*Origin.*—The mylo-hyoid ridge, or internal oblique line, of the inferior maxilla.

Insertion.—The **posterior fibres** are inserted into the anterior surface of the body of the hyoid bone ; and the **principal part** of the muscle is inserted into a central fibrous raphé, which extends

from the symphysis of the inferior maxilla on its deep and lower aspect to the body of the hyoid bone.

Nerve-supply.—The mylo-hyoid branch of the inferior dental nerve, which is a branch of the inferior maxillary division of the fifth cranial nerve.

The muscle is directed downwards and forwards.

Action.—(1) To raise the floor of the mouth, and, in doing so, to press the tongue against the hard palate, as in the first stage of the act of deglutition; (2) to elevate the hyoid bone, and draw it forwards; and (3) to depress the inferior maxilla.

The two mylo-hyoid muscles form a muscular floor for the buccal cavity, which is known as the *diaphragma oris.*

Relations—*Superficial or Inferior.*—The anterior belly of the digastric; the superficial part of the submaxillary gland, lodging a portion of the facial artery; and the mylo-hyoid nerve and submental branch of the facial artery.

Posterior Border.—Passing beneath the posterior free border of the muscle there are the following structures, in order from above downwards: (1) the lingual nerve; (2) a portion of the submaxillary gland; and (3) the hypoglossal nerve, and the ranine vein.

Deep or Superior.—The hyo-glossus muscle, and, resting upon it, (1) the lingual nerve, (2) the submaxillary ganglion, (3) the deep part of the submaxillary gland and Wharton's duct, (4) the hypoglossal nerve, and (5) the ranine vein. In front of the hyo-glossus is the genio-hyoid muscle, and between it and the hyo-glossus is a portion of the genio-hyo-glossus, with the sublingual gland resting upon it.

Genio-hyoid—*Origin.*—The lower genial spine of the inferior maxilla, close to the symphysis on its deep aspect.

Insertion.—The inner two-thirds of the anterior surface of the body of the hyoid bone over its upper part. At its insertion the muscle is divided externally into two laminæ, anterior and posterior, the former of which extends furthest out upon the hyoid bone. The innermost fibres of origin of the hyo-glossus pass inwards between these two laminæ.

Nerve-supply.—The hypoglossal nerve, the branch of which is regarded as being composed of spinal fibres.

The muscle is directed downwards and slightly backwards.

Action.—(1) To elevate the hyoid bone and draw it forwards, and (2) to depress the inferior maxilla.

The muscle is in intimate contact with its fellow of the opposite side at the median line. Its inferior or superficial surface is covered by the mylo-hyoid, and its superior or deep surface is related to the lower or posterior border of the genio-hyo-glossus.

Genio-hyo-glossus—*Origin.*—The upper genial spine of the inferior maxilla, close to the symphysis on its deep aspect.

Insertion.—(1) The under surface of the tongue close to the median line, and extending from near the tip to the root; (2) the inner part

of the anterior surface of the body of the hyoid bone close to its upper margin ; and (3) slightly into the side of the pharynx, where the fibres blend with those of the middle constrictor muscle.

Nerve-supply.—The hypoglossal nerve, the branches of which enter the outer surface of the muscle.

The upper or anterior fibres arch upwards and forwards, and the lower downwards and backwards, whilst the intervening fibres spread out in a diverging manner.

Action.—(1) The entire glossal fibres depress the tongue at the

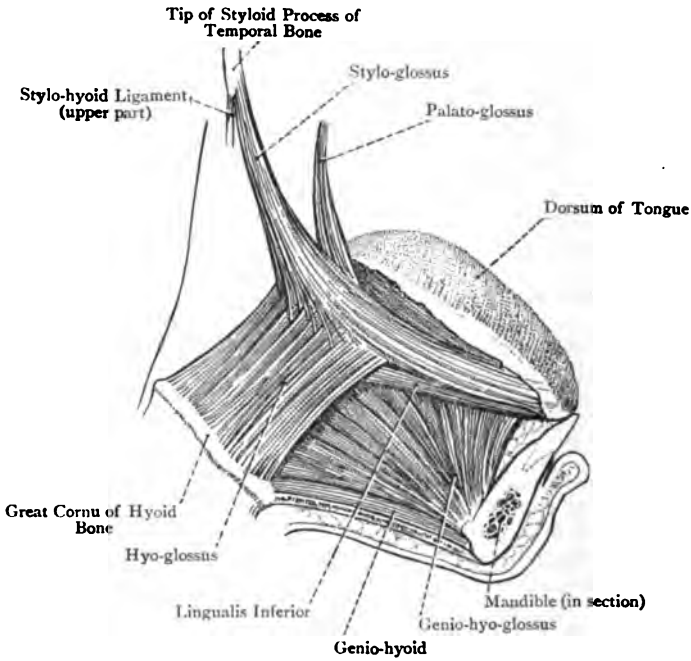


FIG. 445.—THE EXTRINSIC MUSCLES OF THE TONGUE. (THE LINGUALIS INFERIOR IS AN INTRINSIC MUSCLE).

median line, and, along with those of the opposite side, they give rise to an antero-posterior groove, or gutter, on the dorsum of the organ ; (2) the posterior glossal fibres draw forwards the tongue, so as to cause its tip to be protruded from the mouth ; (3) the anterior glossal fibres retract the tip of the tongue when it has been protruded from the mouth ; and (4) the lower or posterior (hyal) fibres elevate the hyoid bone, and draw it forwards.

The muscle is fan-shaped. The internal surface is closely applied to that of its fellow of the opposite side. The external surface is related to the inferior lingualis muscle, the ranine artery, the hyo-

glossus and stylo-glossus muscles, and the sublingual gland. The upper or anterior border is covered by the buccal mucous membrane, and the lower or posterior border by the genio-hyoid muscle.

Hyo-glossus—*Origin.*—(1) The great cornu of the hyoid bone over its entire length; (2) the anterior surface of the body of the bone over about its outer half; and (3) the small cornu (inconstant). The innermost fibres of origin from the hyoid bone pass inwards between the two laminæ of the genio-hyoid muscle.

Insertion.—The posterior half of the under surface of the tongue close to its lateral border, the fibres being situated internal to those of the stylo-glossus, and both sets of fibres being intimately intermixed with each other and with the intrinsic lingual muscles.

Nerve-supply.—The hypoglossal nerve, the branches of which enter the superficial surface.

The muscle is for the most part directed upwards, but its anterior fibres have a slight inclination forwards.

Action.—(1) To depress the side of the tongue, and, along with its fellow, to render the dorsum of the organ convex; and (2) to assist in retracting the protruded tongue.

The hyo-glossus is a flat, four-sided muscle.

Relations—*Superficial.*—The mylo-hyoid muscle; the intervening tendon of the digastric, and stylo-hyoid muscle; the lingual nerve, with the submaxillary ganglion lying a little below it; the deep part of the submaxillary gland, and Wharton's duct; the hypoglossal nerve; and the ranine vein. *Posterior Border.*—The following structures pass beneath this border, in order from above downwards: (1) the glosso-pharyngeal nerve; (2) the stylo-hyoid ligament; and (3) the lingual artery. *Deep.*—The posterior part of the genio-hyo-glossus; a portion of the middle constrictor muscle of the pharynx; the lingual artery; the lower end of the stylo-hyoid ligament; and the glosso-pharyngeal nerve.

The fibres of the hyo-glossus which arise from the small cornu of the hyoid bone are separated from the rest of the muscle by those fibres of the genio-hyo-glossus which take insertion into the side of the pharynx, and they are regarded by some as a separate muscle, called the *chondro-glossus.* These fibres, however, are inconstant.

Stylo-glossus—*Origin.*—(1) The front of the styloid process of the temporal bone near its tip; and (2) the upper extremity of the stylo-mandibular ligament.

Insertion.—The under surface of the tongue close to its lateral border. The fibres extend as far forwards as the tip, and are situated external to the fibres of the hyo-glossus, both sets of fibres being intimately intermixed with each other, and with the intrinsic lingual muscles.

Nerve-supply.—The hypoglossal nerve.

The muscle is directed downwards, forwards, and inwards.

Action.—(1) To draw the tongue backwards; and (2) to elevate the root of the tongue.

Stylo-hyoid Ligament.—This is a narrow fibrous cord which is attached superiorly to the tip of the styloid process, and inferiorly to the small cornu of the hyoid bone. Its direction is downwards and forwards, and its lower extremity is covered by the hyo-glossus muscle. It is liable to become ossified, more or less completely.

Submaxillary Gland.—This gland is situated in the anterior part of the submaxillary or digastric triangle. It consists of a large superficial part and a small deep part. The *superficial part* superiorly occupies the submaxillary fossa on the inner surface of the body of the inferior maxilla, and inferiorly it is covered by the skin, superficial fascia, platysma myoides, and deep fascia. The facial vein descends over it. Its deep surface rests anteriorly upon the mylo-hyoid muscle, with the intervention of the mylo-hyoid nerve and submental branch of the facial artery; and posteriorly upon the hyo-glossus, and slightly upon the posterior belly of the digastric and stylo-hyoid, muscles. The superficial part is grooved at its upper and back part by the facial artery, which lies embedded in the gland. Posteriorly the superficial part is related to the cervical portion of the parotid gland, from which it is separated by the stylo-mandibular (stylo-maxillary) ligament. The *deep part* of the gland is of small size, and is continuous with the superficial part at the posterior border of the mylo-hyoid muscle. It lies under cover of that muscle upon the hyo-glossus, and is related to the sublingual gland.

FIG. 446.—SECTION OF THE SUBMAXILLARY GLAND OF A DOG.

The **duct** of the submaxillary gland is known as **Wharton's duct,** and it emerges from the deep aspect of the superficial part of the gland close to the posterior border of the mylo-hyoid muscle. It is about 2 inches in length, and it passes inwards upon the hyo-glossus muscle, lying beneath the deep part of the gland. In this situation it has the submaxillary ganglion and lingual nerve above it, and the hypoglossal nerve below it. After leaving the hyo-glossus muscle, the duct lies upon the genio-hyo-glossus, and, passing slightly upwards, it is crossed from above downwards by the lingual nerve. Having passed beneath the sublingual gland, the duct opens upon the floor of the mouth by a minute orifice, which is situated on the summit of a papilla lying close to the side of the frenum of the tongue.

The submaxillary gland is enclosed in a capsule, which is derived from the deep cervical fascia.

Blood-supply.—The gland derives its blood chiefly from the cervical part of the facial artery.

Nerve-supply.—The nerves are derived from the submaxillary ganglion, and through this from (1) the chorda tympani, (2) the lingual, and (3) the sympathetic plexus on the facial artery.

Lymphatics.—These pass to the submaxillary lymphatic glands, and thence to the superficial and deep cervical glands.

Structure.—The submaxillary gland is a **muco-serous gland,** and its general structure is similar to that of the parotid gland. The essential difference between the two has reference to the alveoli or acini, and the nature of their secretion. The cells of the parotid alveoli are *serous* or *albuminous*. The submaxillary alveoli contain, around the lumen, *mucous cells* filled with granular mucigen, which is discharged as mucus. They, however, also contain some albuminous cells, known as the *marginal cells*, which are situated, external

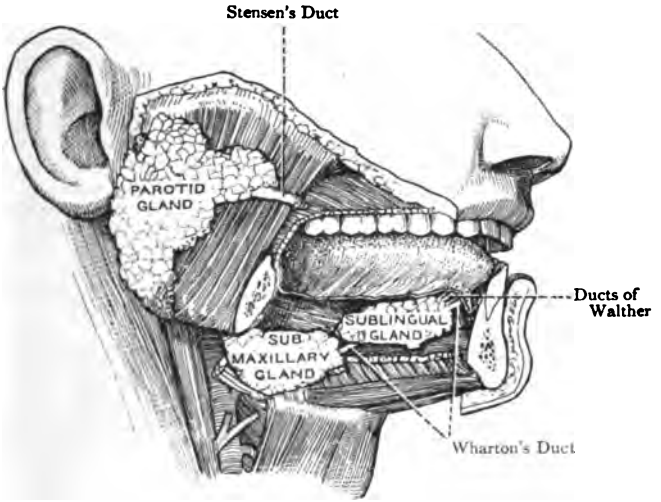


FIG. 447.—THE SALIVARY GLANDS OF THE RIGHT SIDE.

to the mucous cells, but within the membrana propria of the alveolus. These cells usually form groups which, from their crescentic arrangement, are known as the *crescents of Gianuzzi*.

Development.—The submaxillary gland is developed as a solid outgrowth of the buccal epithelium. This outgrowth undergoes ramifications, and these subsequently become hollow.

Sublingual Gland.—This is the smallest of the salivary glands, and resembles an almond in shape. It measures about 1½ inches in length, and is situated beneath the mucous membrane of the floor of the mouth, where it gives rise to a mucous fold, called the *plica sublingualis*. Inferiorly it rests upon the mylo-hyoid muscle (under cover of it), and is here related to the deep part of the submaxillary gland, Wharton's duct, and the lingual nerve. Externally it occupies the sublingual fossa on the inner surface of the body of the inferior maxilla above the mylo-hyoid ridge; and internally it is in contact with the genio-hyo-glossus muscle. Its mesial

extremity comes into contact with its fellow of the opposite side over the anterior border of the genio-hyo-glossus muscle.

The **sublingual ducts** vary in number from ten to twenty, and are known as the *ducts of Walther* (ducts of Rivini). A few of them open into Wharton's duct, but the majority open in a linear manner upon the summit of the plica sublingualis. One of the ducts, called the *duct of Bartholin*, or *great duct of Rivini*, issues from the external lobule of the gland, and, accompanying Wharton's duct, it opens quite close to the orifice of that duct.

Blood-supply.—The gland derives its blood from the sublingual branch of the lingual, and the submental branch of the facial, arteries.

Nerve-supply.—The nerves are derived from the chorda tympani and lingual nerves, and the sympathetic plexus on the facial artery, through means of a branch of the submaxillary ganglion, which is conducted to the sublingual gland by the lingual nerve.

Structure.—The sublingual gland is a **mucous gland,** and its general structure is similar to that of the parotid and submaxillary glands, but the lobules are more loosely arranged. The cells of the sublingual alveoli are for the most part *mucous cells*, but there are also serous or albuminous cells.

Development.—The sublingual gland is developed as a solid outgrowth of the buccal epithelium. This outgrowth undergoes ramifications, and these subsequently become hollow.

Scalene Muscles and Subclavian Artery.

Scalene Muscles.—The scalene muscles are three in number, namely, scalenus anticus, scalenus medius, and scalenus posticus.

Scalenus Anticus—*Origin.*—By four short tapering tendons from the tubercles of the costal processes (anterior tubercles of the transverse processes) of the third, fourth, fifth, and sixth cervical vertebræ.

Insertion.—The scalene tubercle of the first rib.

Nerve-supply.—The anterior primary divisions of the fourth, fifth, and sixth cervical nerves.

The muscle is directed downwards, outwards, and forwards.

Action.—(1) To fix the first rib in ordinary inspiration, and to elevate it in forced inspiration ; and (2) to flex the neck to one side and slightly forwards.

Chief Relations—*Anterior.*—The phrenic nerve, which crosses the muscle obliquely downwards and inwards ; the internal jugular vein, which lies over its origin ; and the subclavian vein close to its insertion. *Posterior.*—The scalenus medius, with the intervention of the second part of the subclavian artery, the nerve-roots of the brachial plexus, and the dome of the pleura. *Internal.*—The ascending cervical artery, and the origin of the rectus capitis anticus major.

Scalenus Medius—*Origin.*—By six short tapering tendons from the tubercles of the transverse processes (posterior tubercles) of the lower six cervical vertebræ.

Insertion.—The upper surface of the first rib from the groove for the subclavian artery backwards to the tubercle.

Nerve-supply.—The anterior primary divisions of cervical nerves from the third to the eighth inclusive.

The muscle is directed downwards and outwards.

Action.—(1) To fix the first rib in ordinary inspiration, and (2) to flex the neck to one side.

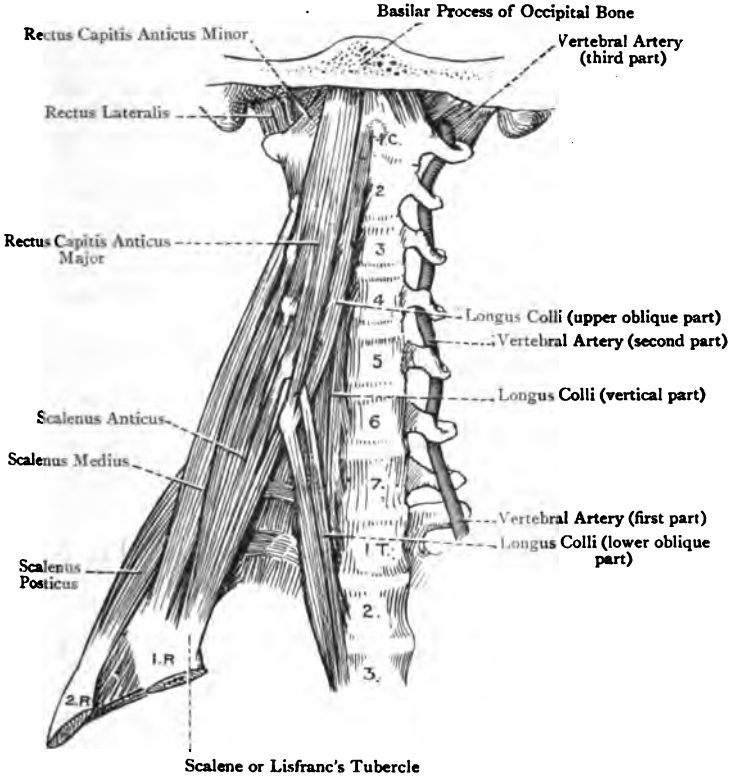


FIG. 448.—THE RIGHT PREVERTEBRAL MUSCLES.

(The Vertebral Artery is also shown).

Relations—*Anterior.*—The cervical plexus, the nerve-roots of the brachial plexus, except the first thoracic, and the second and third parts of the subclavian artery. *Posterior.*—The levator anguli scapulæ and scalenus posticus muscles.

The scalenus medius is pierced by the following nerves: (1) the nerve to the rhomboids, which passes in a backward direction; and (2) the upper and middle roots of the posterior thoracic nerve, or external respiratory nerve of Bell. These two roots usually emerge

from the muscle as a single cord, and the lower or third root of the nerve descends in front of the scalenus medius, and joins the foregoing cord about the level of the first rib.

Scalenus Posticus—*Origin.*—By two or three short tendons from the tubercles of the transverse processes (posterior tubercles) of the lower two or three cervical vertebræ.

Insertion.—The upper part of the outer surface of the second rib, in front of the insertion of the highest slip of the serratus posticus superior, and behind the origin of a portion of the first, and the second, serrations of the serratus magnus.

Nerve-supply.—The anterior primary divisions of the sixth, seventh, and eighth cervical nerves, the branches of which pass through the scalenus medius.

The muscle is directed downwards and outwards.

Action.—(1) To elevate the second rib, and (2) to flex the neck to one side.

Relations—*Anterior.*—The scalenus medius. *Posterior.*—The lower two tendons of origin of the levator anguli scapulæ. The scalenus posticus is intimately connected with the scalenus medius, of which it may be regarded as a detached part.

Subclavian Artery.—The right subclavian vessel arises from the innominate artery behind the right sterno-clavicular joint on a level with its upper part, and the left subclavian vessel arises from the upper aspect of the arch of the aorta towards its back part. On each side the artery terminates at the outer border of the first rib by becoming the axillary artery. In its course the vessel is crossed superficially by the scalenus anticus muscle, which divides it into three parts, first, second, and third.

The **first part** extends from the origin of the vessel to the inner border of the scalenus anticus; the **second part** lies behind that muscle; and the **third part** extends from the outer border of the muscle to the outer border of the first rib. The total length of the vessel on the right side is about 3 inches, and, on the left, about 4½ inches. The artery describes an arch over the apex of the corresponding lung and pleura, and the height to which it rises above the clavicle is about ½ inch.

First Part of the Right Subclavian Artery.—This part extends from the bifurcation of the innominate artery behind the right sterno-clavicular joint, on a level with its upper part, to the inner border of the scalenus anticus muscle. Its direction is upwards and outwards, and it lies very deeply.

Relations—*Anterior.*—The skin, superficial fascia and platysma myoides, deep cervical fascia, clavicular origin of the sterno-cleido-mastoid, and sterno-hyoid and sterno-thyroid muscles. Three veins are related to it superficially. The internal jugular and vertebral veins cross it from above downwards close to the scalenus anticus, the latter vessel being under cover of the former, and the anterior jugular vein crosses it from within outwards, but superficial to the sterno-hyoid and sterno-thyroid muscles. Important

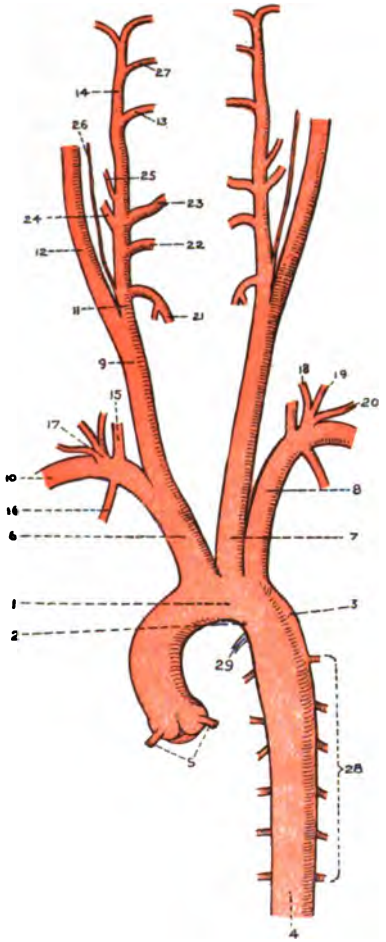


FIG. 449.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Internal Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyroid Axis
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Aortic Intercostals
29. Lig. Ductûs Arteriosi

nerves also cross it superficially, namely, the pneumogastric and its cervical cardiac branches, the cervical cardiac branches of the sympathetic, and the nerve-loop known as the ansa Vieussenii. *Posterior.*—The recurrent laryngeal nerve, gangliated cord of the sympathetic, fat, longus colli muscle, first thoracic vertebra, dome of the pleura, and apex of the lung. *Inferior.*—The recurrent laryngeal nerve, part of the ansa Vieussenii, and the pleura.

The right subclavian and right internal jugular veins unite anterior to this part of the vessel to form the right innominate vein.

First Part of the Left Subclavian Artery.—This part extends from the upper aspect of the arch of the aorta, towards its back part, to the inner border of the scalenus anticus muscle. It is therefore placed at first in the thoracic cavity. Its course is almost vertical until it reaches the root of the neck, where it curves sharply outwards upon the dome of the pleura, and so reaches the scalenus anticus. The relations of the intrathoracic portion have been described in connection with the thorax (see p. 904).

Cervical Relations—*Anterior.*—The skin, superficial fascia and platysma myoides, deep cervical fascia, clavicular origin of the sterno-cleido-mastoid, sterno-hyoid and sterno-thyroid muscles, and the thoracic duct which arches over it. The left internal jugular and subclavian veins unite in front of it to form the left innominate vein, and the left vertebral vein descends in front of it under cover of the left internal jugular vein. *Posterior.*—The gangliated cord of the left sympathetic with the inferior cervical ganglion, fat, and the left longus colli muscle. *Right.*—The trachea, œsophagus, left recurrent laryngeal nerve, and thoracic duct.

The varieties in origin of the subclavian artery have been described in connection with the arch of the aorta (see p. 906).

Second Part of the Subclavian Artery.—This portion of the vessel is situated behind the scalenus anticus muscle. It lies about ½ inch above the clavicle, and forms the highest part of the arch described by the vessel.

Relations—*Anterior.*—The skin, superficial fascia and platysma myoides, deep cervical fascia, clavicular part of the sterno-cleido-mastoid, scalenus anticus, phrenic nerve on the right side, and subclavian vein, the latter vessel being on a lower level than the artery, and separated from it by the scalenus anticus. *Posterior.*—The pleura. *Superior.*—The nerve-roots of the brachial plexus. *Inferior.*—The pleura.

In some cases the second part of the vessel passes through the scalenus anticus, and in rare cases it passes in front of the muscle.

For the third part of the subclavian artery, see p. 1020.

Development.—The *right* subclavian artery, as far as the origin of the internal mammary artery, is developed from the fourth right arterial arch.

The *left* subclavian artery is developed from a segmental artery.

Branches of the Subclavian Artery.—These are four in number, namely, the vertebral, internal mammary, thyroid axis, and

superior intercostal. The first three arise from the *first part* of the artery towards its termination, and the last arises from the *second part* on the **right** side, and from the *first part* on the **left** side.

Vertebral Artery.—This is the first branch in order. On the right side it arises from the upper and back part of the artery about an inch from its origin, and on the left side from the vessel just after it enters the root of the neck. It passes for a short distance upwards, backwards, and slightly outwards, and disappears from view by entering through the costo-transverse (vertebrarterial) foramen in the transverse process of the sixth cervical vertebra as a rule. It then ascends vertically through the successive costo-transverse foramina above that of the sixth vertebra, and in passing from that of the axis to that of the atlas it describes a bend outwards. Having traversed the costo-transverse foramen of the atlas, it passes backwards and inwards, lying in the vertebrarterial groove on the upper surface of the posterior arch of the atlas behind the superior articular process. Thereafter it pierces the dura mater and arachnoid, and, having reached the side of the spinal cord, it turns upwards in the subarachnoid space, and enters the cranial cavity through the foramen magnum. Being now related to the medulla oblongata, it gradually inclines from its lateral to its ventral aspect, and at the lower border of the pons Varolii it joins its fellow to form the basilar artery.

On account of its complicated course, the vertebral artery is divided into four parts, namely, first or cervical, second or costo-transverse, third or suboccipital, and fourth or intracranial.

The **first** or **cervical part** extends from the origin of the vessel to the costo-transverse foramen in the transverse process of the sixth cervical vertebra. It lies between the scalenus anticus and longus colli muscles, having the internal jugular and vertebral veins in front of it; being crossed by the inferior thyroid artery; and having the sympathetic gangliated cord and the transverse process of the seventh cervical vertebra behind it. The vessel of the left side has the thoracic duct as an additional anterior relation.

The first part gives off no branches.

The **second** or **costo-transverse part** traverses the costo-transverse foramina of the cervical vertebræ from, as a rule, the sixth upwards. It is surrounded by the vertebral venous plexus, and by the vertebral plexus of the sympathetic, and it lies in front of the cervical spinal nerves as these emerge from the intervertebral foramina.

Branches.—These are as follows: lateral spinal and muscular. The *lateral spinal branches* enter the spinal canal through the intervertebral foramina. The *muscular branches* supply the deep muscles of the neck, and anastomose with the deep cervical, ascending cervical, and occipital arteries.

For the third or suboccipital, and the fourth or intracranial, parts of the vertebral artery, see pp. 990, 1346).

Varieties.—(1) The left vertebral artery occasionally arises from the arch of the aorta between the origins of the left common carotid and left subclavian

arteries. (2) The vessel may pass the costo-transverse foramen of the sixth cervical vertebra, and may enter that of the fifth, or even that of the fourth. (3) The vessel has been found in rare cases to enter the costo-transverse foramen of the seventh cervical vertebra.

Internal Mammary Artery.—This vessel is so named in contradistinction to the *external mammary*, or *long thoracic*, which is a branch of the second part of the axillary artery. It arises from the lower aspect of the first part of the subclavian artery very nearly opposite the thyroid axis. Its course is downwards, forwards, and slightly inwards, and it disappears behind the sternal end of the clavicle and first costal cartilage. For its subsequent course and relations, see p. 875.

Relations of Cervical Part—*Anterior.*—The clavicular part of the sterno-cleido-mastoid, and the internal jugular and subclavian veins. The phrenic nerve crosses the vessel superficially from without inwards. *Posterior.*—The pleura.

No branches arise from this part of the vessel.

Thyroid Axis.—This is a short trunk which springs from the front of the first part of the subclavian artery close to the inner border of the scalenus anticus muscle. It almost immediately divides into three diverging branches, namely, inferior thyroid, transverse cervical, and suprascapular.

The **inferior thyroid artery** passes upwards and inwards in a tortuous manner in front of the vertebral artery, and behind the carotid sheath and sympathetic nerve, the middle cervical ganglion of which latter rests upon it. Having reached the lower part of the lateral lobe of the thyroid body, the artery breaks up into its terminal branches, which enter the lobe on its deep aspect, and ramify in it, anastomosing with the superior thyroid, and with its fellow of the opposite side in the isthmus. As the vessel ascends it is intimately related to the recurrent laryngeal nerve, which usually lies behind it.

Branches.—These are as follows : muscular, ascending cervical, inferior laryngeal, tracheal, and œsophageal.

The *muscular branches* supply the scalenus anticus, longus colli, depressor muscles of the hyoid bone, and inferior constrictor of the pharynx. The *ascending cervical artery* arises from the inferior thyroid as it passes inwards behind the carotid sheath. It ascends in front of the transverse processes of the cervical vertebræ, lying between the scalenus anticus and rectus capitis anticus major, and having the phrenic nerve on its outer side. It anastomoses with branches of the vertebral, occipital, and ascending pharyngeal arteries. It may furnish some spinal branches which enter the spinal canal through the intervertebral foramina, to be distributed in a manner similar to the other spinal arteries. The *inferior laryngeal artery* accompanies the recurrent laryngeal nerve to the larynx. The *tracheal* and *œsophageal* branches are distributed as their names suggest.

The **transverse cervical artery** passes transversely outwards in front of the scalenus anticus and phrenic nerve, and behind the

clavicular part of the sterno-cleido-mastoid, lying a little above the clavicle, and also above the suprascapular artery. It then enters the subclavian triangle, which it soon leaves by passing beneath the posterior belly of the omo-hyoid. Thereafter it passes in front of, or between, the nerve-trunks of the brachial plexus, and beneath the trapezius muscle. Having reached the anterior border of the levator anguli scapulæ, it divides into its two terminal branches—superficial cervical and posterior scapular.

The *superficial cervical artery* passes superficial to the levator anguli scapulæ, and is distributed to the trapezius, levator anguli scapulæ, splenius, and the adjacent lymphatic glands. The *posterior scapular artery* passes backwards beneath the levator anguli scapulæ to the superior angle of the scapula. Thereafter it descends along the base of the bone, under cover of the rhomboid muscles, as far as the lower angle, where it anastomoses with the teres branch of the dorsalis scapulæ of the subscapular from the third part of the axillary artery. The artery gives branches to the adjacent muscles, and ventral and dorsal branches to the scapula, which take part in the scapular anastomoses proper (see p. 304).

The posterior scapular artery is frequently a branch of the third part of the subclavian, in which cases there is no transverse cervical artery, the superficial cervical artery taking its place and arising from the thyroid axis.

The **suprascapular artery** (transversalis humeri) passes downwards and outwards in front of the scalenus anticus and phrenic nerve, and behind the clavicular part of the sterno-cleido-mastoid. Having reached the back of the clavicle, it courses outwards behind that bone, passing in front of the third part of the subclavian artery and the trunks of the brachial plexus. It then passes to the upper border of the scapula, in company with the suprascapular nerve. For the further course of the vessel see p. 300; and for the scapular anastomoses of arteries see p. 304.

Branches in the Neck.—These are as follows: muscular, suprasternal, and medullary. The *muscular branches* supply the sterno-cleido-mastoid and subclavius. The *suprasternal branch* descends over the inner end of the clavicle to supply the integument over the manubrium sterni. The *medullary artery* of the clavicle is directed *outwards*, and enters the medullary foramen of that bone.

Superior Intercostal Artery.—This vessel arises from the second part of the subclavian on the right side, and from the first part on the left side, in each case from the posterior aspect of the parent trunk. On the right side it is therefore behind the scalenus anticus, and on the left side close to the inner border of that muscle. The vessel at first passes backwards for a short distance, and then descends in front of the neck of the first rib. At the posterior extremity of the first intercostal space it furnishes the first intercostal artery to that space, and then descends in front of the neck of the second rib to become the second intercostal artery. The superior intercostal artery, therefore, furnishes the first and second

intercostal arteries for the first and second intercostal spaces, their distribution being similar to that of the succeeding aortic intercostal arteries. Besides these two branches, the vessel gives off the *deep cervical artery*. This branch, which is homologous with the dorsal branch of an aortic intercostal artery, arises from the superior intercostal before it descends in front of the neck of the first rib. It passes backwards between the transverse process of the seventh cervical vertebra and the neck of the first rib, and then ascends between the complexus and semispinalis colli muscles to about the level of the axis. In this latter situation it anastomoses with the deep branch of the ramus cervicalis princeps of the occipital from the external carotid. The deep cervical in its course gives off muscular branches which anastomose with branches of the vertebral and ascending cervical arteries. It also furnishes a spinal branch which enters the spinal canal through the intervertebral foramen between the seventh cervical and first thoracic vertebræ.

The first part of the right subclavian artery sometimes gives off a small branch, which is known as the **aberrant artery.** It arises near the vertebral, or sometimes from the superior intercostal, and passes obliquely downwards and inwards between the œsophagus and the vertebral column. In the thorax it ends by joining the back of the arch of the aorta close to its termination, or by anastomosing with an offset from that part of the arch. The vas aberrans is regarded as representing the remains of the right aortic root, and an enlargement of it would account for the rare origin of the right subclavian artery from the back part of the aortic arch near its termination, and for the course of the abnormal vessel behind the œsophagus as it passes to take up its position on the right side.

Subclavian Vein.—This vessel, which is the direct continuation of the axillary vein, extends from the outer border of the first rib to the back of the inner end of the clavicle, where it unites with the internal jugular to form the innominate vein. It lies in front of, and on a lower plane than, the subclavian artery, and it passes in front of the scalenus anticus muscle and phrenic nerve. In rare cases the vein has been met with passing behind the scalenus anticus. Its principal tributary is the external jugular vein (sometimes also the anterior jugular). The external jugular vein joins it close to the outer border of the sterno-cleido-mastoid.

The thoracic duct opens in the angle of junction of the left subclavian and left internal jugular veins, and the right lymphatic duct opens into the angle of junction of the corresponding veins on the right side.

Vertebral Vein.—This vein commences in the suboccipital venous plexus within the suboccipital triangle. It passes through the costo-transverse foramen in the altas, and accompanies the vertebral artery through the succeeding costo-transverse foramina as low as the sixth, forming a plexus around the vessel. This plexus is ultimately replaced by a single vein, which emerges through the costo-transverse foramen in the sixth cervical vertebra (sometimes the seventh). It then descends in front of the first part of the subclavian artery, under cover of the internal jugular vein, and

opens into the back part of the innominate vein, the opening being provided with a single or double valve.

The **chief tributaries** of the vertebral vein are as follows: muscular, spinal, anterior vertebral, and deep cervical. It also, as a rule, receives the first intercostal vein.

No vein accompanies the cervical part of the internal mammary artery. The **inferior thyroid vein,** which does not accompany the corresponding artery, will be found described in connection with the thyroid body (see p. 1048).

The **transverse cervical** and **suprascapular veins** return the blood from the parts supplied by the corresponding arteries, and are tributaries of the lower part of the external jugular vein.

The **deep cervical vein** (posterior vertebral vein) commences in the suboccipital venous plexus within the suboccipital triangle. It descends in company with the deep cervical artery, and passes forwards between the transverse process of the seventh cervical vertebra and the neck of the first rib to terminate in the vertebral vein.

The **anterior vertebral vein** commences in a plexus in front of the upper cervical transverse processes. It descends in company with the ascending cervical branch of the inferior thyroid artery, receiving muscular tributaries in its descent, and it opens into the lower part of the vertebral vein.

Collateral Circulation after Ligation of the Third Part of the Subclavian Artery.—(1) The suprascapular and the posterior scapular branch of the transverse cervical, both branches of the thyroid axis from the first part of the subclavian, take part in the scapular anastomoses, and anastomose freely with branches of the first and third parts of the axillary artery. (2) The internal mammary from the first part of the subclavian anastomoses with the long thoracic from the second part of the axillary.

Collateral Circulation after Occlusion of the First Part of the Subclavian Artery.—(1) The vertebral artery of one side anastomoses with that of the opposite side. (2) The internal mammary anastomoses with the deep epigastric from the external iliac, and with the aortic intercostal arteries. (3) The inferior thyroid anastomoses with the superior thyroid from the external carotid. (4) The superior intercostal anastomoses with the first aortic intercostal. (5) The deep cervical of the superior intercostal anastomoses with the deep branch of the ramus cervicalis princeps of the occipital from the external carotid. (6) The scapular branches of the thyroid axis anastomose with branches of the axillary artery. (7) The thoracic branches of the axillary artery anastomose with the aortic intercostals.

Cervical Part of the Thoracic Duct.—This part of the thoracic duct occupies the root of the neck on the *left side*, and lies upon the side of the œsophagus, between the left common carotid and left subclavian arteries. In this position it ascends to about the level of the seventh cervical vertebra, and then it describes a

curve and passes outwards, forwards, and downwards in contact with the dome of the left pleura. Thereafter it inclines inwards, and, after receiving the left jugular and axillary lymphatic trunks, terminates in the angle of junction of the internal jugular and subclavian veins of the left side. The terminal orifice of the duct is guarded by a valve composed of two segments, which are so directed as to effectually prevent the reflux of chyle, and the flow of blood, into it. The duct crosses the left verterbal artery, and subsequently the left subclavian artery.

Right Lymphatic Duct.—The position of this duct corresponds to that of the thoracic duct on the left side. It is about ½ inch in length, and is formed by the union of the right axillary lymphatic trunk and right jugular lymphatic trunk. Besides returning lymph from the right side of the head and neck and the right upper limb, it receives the lymphatic vessels from the right side of the heart, the right lung, the upper part of the right half of the thoracic wall, and some of those from the supero-anterior surface of the liver. It terminates in the angle of junction of the internal jugular and subclavian veins of the corresponding side, its orifice being guarded by a double valve.

Cervical Portion of the Lung —The apex of the lung projects into the root of the neck for from 1 to 1½ inches. It is covered by the dome of the pleura, on the inner and anterior aspects of which the subclavian artery arches outwards. The dome of the pleura is covered by **Sibson's fascia,** which extends from the internal border of the first rib to the front of the transverse process of the seventh cervical vertebra. This fascia is probably derived from the adjacent scalene muscles, and it may contain some muscular fibres.

The Orbit.

The contents of the orbit are as follows : (1) the eyeball and the optic nerve ; (2) the capsule of Tenon ; (3) seven muscles, six of which belong to the eyeball, namely, the four recti and two obliqui, whilst the seventh belongs to the upper eyelid, and is called the levator palpebræ superioris ; (4) the third, fourth, and sixth cranial nerves, the three branches of the ophthalmic division of the fifth cranial nerve, namely, frontal, lachrymal, and nasal, and the orbital or temporo-malar branch of the superior maxillary division of the fifth cranial nerve ; (5) the ciliary, lenticular, or ophthalmic ganglion ; (6) the lachrymal gland ; and (7) a quantity of soft fat. The foregoing contents are surrounded by a fibrous sheath which is formed by the periosteum.

Periosteum.—The periosteum of the orbit is continuous posteriorly with the dura mater through the sphenoidal fissure. Anteriorly it becomes continuous with the pericranium of the frontal bone, and the periosteum of the superior maxillary and malar bones. Along the supra-orbital and infra-orbital margins the superior and inferior palpebral ligaments blend with it. The

periosteum is loosely attached to the bony walls of the orbit, and forms a sheath for the contents of the cavity, which is incomplete in front.

Lachrymal Gland.—This gland lies at the anterior and outer part of the orbit superiorly, where it occupies the lachrymal fossa on the inner side of the external angular process of the frontal bones. It is almond-shaped. Its upper surface is convex, and its under surface is concave in adaptation to the eyeball. The anterior part of the gland is more or less detached, and is known as the *palpebral portion*, the chief part being known as the *orbital portion*. The **duets**, which issue from both portions, are about twelve in number, and they open in a row into the outer part of the superior *fornix conjunctivæ*.

Blood-supply.—The lachrymal artery.

Nerve-supply.—The lachrymal nerve, and sympathetic filaments.

The **structure** of the gland is similar to that of the parotid gland.

Muscles.—These are seven in number, as follows : levator palpebræ superioris, superior rectus, inferior rectus, internal rectus, external rectus, superior oblique, and inferior oblique.

Levator Palpebræ Superioris—*Origin.*—The under surface of the roof of the orbit above, and in front of, the optic foramen.

Insertion.—By a broad membranous expansion, which divides into three layers. The *middle layer*, which represents the chief insertion, and consists largely of involuntary muscular fibres, is attached to the upper margin of the superior tarsal plate. The *upper* or *superficial layer*, which is fibrous, passes over, or in front of, the superior tarsal plate, lying between it and the palpebral fibres of the orbicularis palpebrarum. Its fibres pierce the superior palpebral ligament, and, having passed between the bundles of the palpebral portion of the orbicularis palpebrarum, they are attached to the skin of the upper eyelid. The *lower* or *deep layer*, which is also fibrous, is attached to the conjunctiva along the superior fornix. The outer and inner margins of the broad membranous expansion are attached to the outer and inner margins of the orbit close to the external and internal tarsal ligaments, and at the inner angle a slip is detached to the pulley of the superior oblique muscle.

Nerve-supply.—The upper division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle near its origin.

Action.—To raise the upper eyelid. The muscle is the antagonist of the superior palpebral fibres of the orbicularis palpebrarum.

Relations.—*Superiorly*, the frontal nerve and the supra-orbital artery. *Inferiorly*, the superior rectus and the conjunctiva.

Recti Muscles—Superior Rectus—*Origin.*—The upper part of the fibrous ring in relation to the optic foramen.

Insertion.—By a thin expanded tendon into the upper surface of the sclerotic about three or four lines from the margin of the cornea.

Nerve-supply.—The upper division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle near its origin.

The muscle is flattened from above downwards, and its direction is forwards and slightly outwards.

Action.—To elevate the eyeball, so as to direct the cornea upwards. The muscle imparts a certain amount of inward movement to the eyeball, accompanied by slight rotation.

Relations.—*Superiorly*, the levator palpebræ superioris, which is the narrower of the two muscles. *Inferiorly*, the soft fat of the orbit.

Internal Rectus—*Origin.*—The upper and lower parts of the fibrous ring in relation to the optic foramen, the origin being wide,

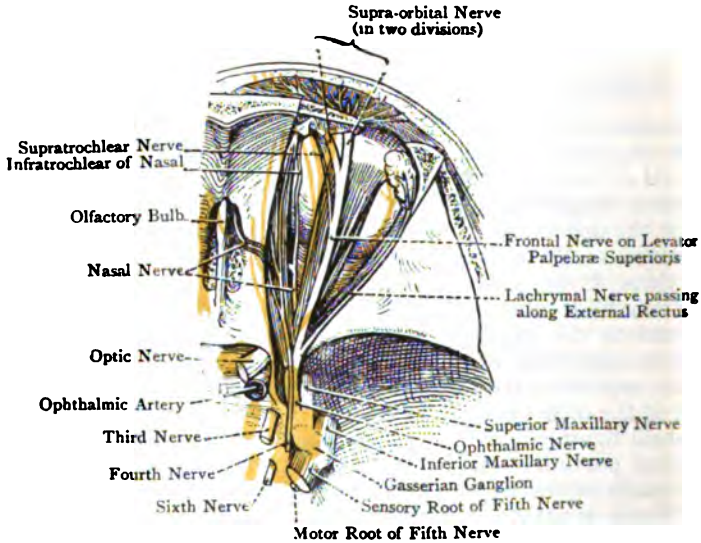


FIG. 450.—DISSECTION OF THE ORBIT FROM ABOVE (HIRSCHFELD AND LEVEILLÉ).

and being situated partly on the inner side of, and partly below, the optic foramen.

Insertion.—By a thin expanded tendon into the inner surface of the sclerotic about three or four lines from the margin of the cornea.

Nerve-supply.—The lower division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle.

The muscle is flattened from within outwards, and its borders are superior and inferior. Its direction is almost straight forwards.

Action.—To adduct the eyeball, so as to direct the cornea inwards.

Relations.—Above the upper border of the muscle is the superior oblique, and between the two the nasal nerve and the anterior and posterior ethmoidal vessels pass.

Inferior Rectus—*Origin.*—The lower part of the fibrous ring in relation to the optic foramen.

Insertion.—By a thin expanded tendon into the lower surface of the sclerotic about three or four lines from the margin of the cornea.

Nerve-supply.—The lower division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle.

The muscle is flattened from above downwards, and its direction is forwards and slightly outwards.

Action.—To depress the eyeball, so as to direct the cornea downwards. The muscle imparts a certain amount of inward movement to the eyeball, accompanied by slight rotation.

Relations—*Inferior.*—A part of the inferior oblique.

External Rectus—*Origin.*—This muscle arises by two heads.

Inferior Head.—(1) The lower part of the fibrous ring in relation to the optic foramen, where it is contiguous to the inferior rectus; and (2) the prominent spine on the lower margin of the sphenoidal fissure near its inner end.

Superior Head.—The outer portion of the upper part of the fibrous ring in relation to the optic foramen, where it is above the sphenoidal fissure, external to the optic foramen, and contiguous to the superior rectus. The two heads are connected by a tendinous band which arches over the sphenoidal fissure, and gives origin to some of the fibres of the inferior head of the muscle.

Insertion.—The outer surface of the sclerotic from three to four lines from the margin of the cornea.

Nerve-supply.—The sixth cranial nerve, the branches of which enter the deep or ocular surface of the muscle.

The muscle is flattened from without inwards, and its direction is forwards and outwards.

Action.—To abduct the eyeball, so as to direct the cornea outwards.

Relations.—The following structures pass between the two heads of the muscle, in order from above downwards: (1) the upper division of the third nerve; (2) the nasal nerve; (3) the lower division of the third nerve; (4) the sixth nerve; and (5) the ophthalmic vein, or veins.

Common Tendon of the Recti Muscles.—This tendon takes the form of a fibrous ring, which is attached to the upper, inner, and lower margins of the optic foramen. It then crosses transversely the inner portion of the sphenoidal fissure to a prominent spine on the lower margin of that fissure near its inner end. From this spine it recrosses the sphenoidal fissure in a vertical direction near its centre, and finally reaches the upper part of the optic foramen. This latter portion gives origin to some fibres of the inferior head of the external rectus. The fibrous ring presents an upper and a lower part. The *upper part* is prolonged forwards into the *superior tendon of Lockwood*, which gives origin from within outwards to part of the internal rectus, the superior rectus, and the superior head of the external rectus. The *lower part* is also

prolonged forwards into the *inferior tendon* or *ligament of Zinn*, which gives origin from within outwards to part of the internal rectus, the inferior rectus, and the inferior head of the external rectus.

Obliqui Muscles—Superior Oblique—*Origin.*—The wall of the orbit directly in front of the upper and inner part of the optic foramen, where it is contiguous to the superior and internal recti.

Insertion.—By an expanded tendon into the upper and outer aspect of the sclerotic, just beyond the outer border of the superior rectus, and midway between the margin of the cornea and the entrance of the optic nerve.

The muscle is situated at the upper and inner part of the orbit, internal to the levator palpebræ superioris. It is directed forwards towards the inner angle of the orbit, on approaching which it ends in a small round tendon. This tendon passes over a fibro-cartilaginous pulley or trochlea, close to the internal angular process of the frontal bone. Thereafter it changes its direction, and passes downwards, outwards, and backwards beneath the tendon of the superior rectus to reach its insertion just external to that tendon.

The fibro-cartilaginous pulley or *trochlea* is attached by fibrous tissue to the *fovea trochlearis* on the orbital plate of the frontal bone close to the internal angular process. It is lined with synovial membrane to lubricate the tendon and facilitate its movement at this abrupt change in its course. The tendon receives a fibrous investment from the outer margin of the pulley.

Nerve-supply.—The fourth cranial nerve, which enters the muscle on its *superficial* or *orbital surface* near its origin.

Action.—To depress and abduct the eyeball, or turn it outwards, the eyeball being at the same time slightly rotated.

Relations—*Superior.*—The roof of the orbit and the superior rectus. *Inferior.*—The upper border of the internal rectus, with the intervention of the nasal nerve, and the anterior and posterior ethmoidal vessels. *External.*—The levator palpebræ superioris.

Inferior Oblique—*Origin.*—A small depression at the anterior and inner part of the floor of the orbit, immediately external to the upper opening of the lachrymal canal.

Insertion.—The outer surface of the sclerotic under cover of the external rectus, and slightly posterior to the level of the insertion of the superior oblique.

Nerve-supply.—The lower division of the third cranial nerve, the branch of which is long and enters the *posterior border* of the muscle.

The muscle at first passes outwards and backwards upon the floor of the orbit beneath the inferior rectus, and then it turns upwards between the sclerotic and the external rectus, where its tendon expands before taking insertion.

Action.—To elevate and abduct the cornea, the eyeball being at the same time slightly rotated.

Relations.—Towards the eyeball the muscle is related to the inferior rectus and the sclerotic, and towards the orbit to the floor

of the cavity and the external rectus. The borders of the muscle are anterior and posterior, the latter, as stated, receiving the nerve-supply.

Movements of the Eyeball.—The movements of the eyeball consist of rotation round a point situated just behind the centre of its antero-posterior axis. When the eyeball rotates round its vertical axis horizontal or lateral movements take place, and the cornea is directed outwards or inwards according to the muscle which acts. The external rectus abducts the eyeball, so as to direct the cornea outwards, and the internal rectus adducts the eyeball, so as to direct the cornea inwards. When the eyeball rotates round its transverse axis vertical or upward and downward movements take place, and the cornea is directed upwards or downwards according to the muscle which acts. The superior rectus elevates the eyeball, and the inferior rectus depresses it. It is to be borne in mind, however, that these two muscles in passing forwards have each a slight inclination *outwards*. Whilst, then, they respectively elevate and depress the eyeball, each of them also imparts to it a certain amount of inward movement, accompanied by slight rotation. In the case of the superior rectus this inward and rotatory movement is corrected by the *inferior oblique* acting in association with it, and in the case of the inferior rectus by the *superior oblique* acting in association with it.

Direct elevation of the eyeball is therefore effected by the superior rectus, aided by the inferior oblique, and *direct depression* of the eyeball is effected by the inferior rectus, aided by the superior oblique. The superior oblique, acting alone, depresses the eyeball, and abducts it, or turns it outwards, and the inferior oblique, acting alone, elevates the eyeball, and abducts it, these movements in each case being accompanied by slight rotation.

Fascia of the Orbit.—This fascia forms (1) the capsule of Tenon, and (2) sheaths for the ocular muscles.

The **capsule of Tenon** forms a connective-tissue covering for the sclerotic coat of the eyeball, and extends from the point of entrance of the optic nerve to near the margin of the cornea. *Posteriorly* it is perforated by the ciliary vessels and nerves, and blends with the dura matral sheath of the optic nerve, and *anteriorly* it passes beneath the ocular conjunctiva, with which it unites near the margin of the cornea. The outer surface of the capsule is in contact with the orbital fat, and anteriorly with the ocular conjunctiva. The inner surface, which is smooth, is separated from the sclerotic by a narrow space, which is crossed by delicate trabeculæ of connective tissue. This interspace is called the **perisclerotic space,** or **Tenon's space,** and is regarded as a lymph space. The capsule of Tenon forms a cavity or socket, within which the eyeball glides with perfect freedom from friction.

The lower part of the capsule of Tenon presents a thickening, which is known as the **suspensory ligament of the eye** (Lockwood). It is attached externally to the malar bone, and internally to the

lachrymal bone, in association with the forward expansions from the sheaths of the external and internal recti muscles. It is expanded beneath the eyeball, to the fore part of which it acts as a sling or support.

The **muscular sheaths** are derived from the capsule of Tenon. The tendons of the six ocular muscles pierce the capsule on their way to their insertions, which latter are under cover of the capsule, each muscle receiving a prolongation from the margin of the cleft in the capsule of Tenon through which its tendon passes. These prolongations extend backwards around the muscles, and ultimately blend with their perimysial sheaths. As regards the superior oblique muscle, the prolongation around its tendon extends upwards, inwards, and forwards as far as the margin of the trochlea, to which it is attached. The prolongation around the tendon of the inferior oblique muscle extends downwards as far as the outer part of the floor of the orbit.

The sheaths of the four recti muscles give off important expansions. The expansion from the sheath of the external rectus is strong, and is attached to the orbital process of the malar bone, and that from the sheath of the internal rectus, also strong, is attached to the lachrymal crest of the lachrymal bone. These two expansions, at their bony attachments, are connected with the lateral extremities of Lockwood's suspensory ligament. The expansion from the sheath of the superior rectus blends with the deep layer of the tendon of the levator palpebræ superioris, and that from the sheath of the inferior rectus is connected with the inferior tarsal plate. These expansions from the sheaths of the recti, especially from those of the external and internal recti, moderate the action of the muscles, and the latter two are hence known as the **check ligaments.**

Nerves in the Orbit—Optic Nerve.—The optic nerve extends forwards and outwards from the optic commissure, and enters the orbit through the optic foramen, having the ophthalmic artery below it at first, and then on its outer side. It receives sheaths from the dura mater and arachnoid, the former being strong, and at its entrance into the orbit it is surrounded by the origins of the four recti muscles. Its direction is forwards and outwards, with a slight inclination downwards, to the back part of the eyeball, where it pierces the sclerotic coat about $\frac{1}{8}$ inch internal to, and a little below, the level of the centre. Thereafter it pierces the choroid coat, and terminates in the nerve fibre-layer of the retina. The lenticular or ciliary ganglion is in close contact with the outer side of the nerve towards the back part of the orbit, and anterior to this the nerve is surrounded by the ciliary nerves and vessels. It is crossed superiorly by the ophthalmic artery, the superior ophthalmic vein, and the nasal nerve. Inferiorly, about $\frac{1}{2}$ inch behind the eyeball, the arteria centralis retinæ enters it as far as the centre, and thereafter runs forward within it to the retina.

Third, or **Oculo-motor, Nerve.**—This nerve, having left the outer wall of the cavernous sinus, breaks up at the sphenoidal fissure into two divisions, upper and lower. These enter the orbit between the two heads of the external rectus muscle, the nasal nerve being situated between the two.

The *upper division* furnishes two branches, which supply the levator palpebræ superioris and the superior rectus, the twigs entering the muscles on their deep or ocular surfaces.

The *lower division*, larger than the upper, furnishes three branches, which supply the internal rectus, the inferior rectus, and the inferior oblique. The twigs to the internal and inferior recti enter these muscles on their deep or ocular surfaces. The branch to the inferior oblique is a long nerve which passes forwards between the inferior and external recti, and its twigs enter the inferior oblique

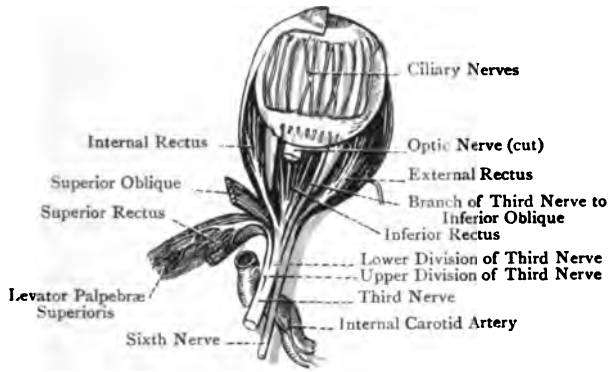


FIG. 451.—THE THIRD AND SIXTH CRANIAL NERVES IN THE ORBIT (HIRSCHFELD AND LEVEILLÉ).

muscle at its *posterior border*. Posteriorly it furnishes the *ganglionic branch*, which forms the short or motor root of the lenticular or ciliary ganglion.

The **fourth, trochlear,** or **pathetic nerve,** of small size, having left the wall of the cavernous sinus, enters the orbit through the sphenoidal fissure above the muscles, and internal to, but on a slightly higher plane than, the frontal nerve. Having passed inwards over the levator palpebræ superioris, it enters the posterior part of the superior oblique muscle on its *superficial* or *orbital surfa e*, this being the only muscle which it supplies.

The **sixth** or **abducent nerve,** having left the cavernous sinus, enters the orbit through the sphenoidal fissure, and passes between the two heads of the external rectus muscle. In this situation it has the lower division of the third nerve above it, and the ophthalmic veins below it. It supplies the external rectus, its twigs entering the muscle on its deep or ocular surface.

Branches of the Ophthalmic Division of the Fifth Nerve.—The ophthalmic nerve, having left the outer wall of the cavernous sinus and before arriving at the sphenoidal fissure, gives off the nasal nerve, and then divides into the frontal and lachrymal nerves.

The **frontal nerve,** of large size, enters the orbit through the sphenoidal fissure above the muscles. In this situation it has the lachrymal nerve external to, and on the same plane with, it, and the fourth nerve internal to it, but on a slightly higher plane. It then passes forwards on the upper surface of the levator palpebræ superioris, underneath the periosteum of the roof of the orbit, and before arriving at the supra-orbital margin it divides into two branches, supra-orbital and supratrochlear.

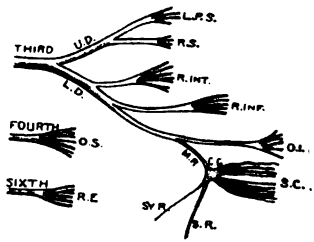


FIG. 452.—SCHEME OF THE DISTRIBUTION OF THE THIRD, FOURTH, AND SIXTH CRANIAL NERVES (FLOWER).

Third Nerve
- U.D. Upper Division
  - L.P.S. Levator Palpebræ Superioris
  - R.S. Rectus Superior
- L.D. Lower Division
  - R.Int. Rectus Internus
  - R.Inf. Rectus Inferior
  - O.I. Obliquus Inferior
- C.G. Ciliary Ganglion
- M.R. Motor Root

S.R. Sensory Root (from Nasal Nerve)
Sy.R. Sympathetic Root
S.C. Short Ciliary Nerves

Fourth Nerve—O.S. Obliquus Superior

Sixth Nerve—R.E. Rectus Externus

The *supra-orbital nerve,* which in size and direction is the continuation of the frontal, passes forwards to the supra-orbital notch, or foramen, through which it emerges in company with the supra-orbital artery. On the forehead it divides into two branches, outer and inner, which have been already described (see p. 992). Sometimes this division takes place within the orbit, and in these cases the inner branch emerges through the frontal notch.

The *supratrochlear nerve,* of small size, passes forwards and inwards to the trochlea or pulley of the superior oblique muscle, above which it emerges on to the forehead, where it has been previously described (see p. 992). Before leaving the orbit it gives off a small twig, which passes downwards, close to the pulley of the superior oblique, to form a loop with the infratrochlear branch of the nasal nerve.

The **lachrymal nerve** enters the orbit through the sphenoidal fissure, above the muscles, and external to the frontal nerve. It then passes forwards and outwards along the upper border of the external rectus muscle, in company with the lachrymal artery. On reaching the lachrymal gland it furnishes numerous branches to its deep surface, and is then continued beneath it through the superior palpebral ligament, to be distributed to the skin and conjunctiva of the outer part of the upper eyelid, and the skin in the region of the external angular process of the frontal bone. Near the lachrymal gland it sends downwards a small twig, which joins the temporal branch of the orbital or temporo-malar nerve.

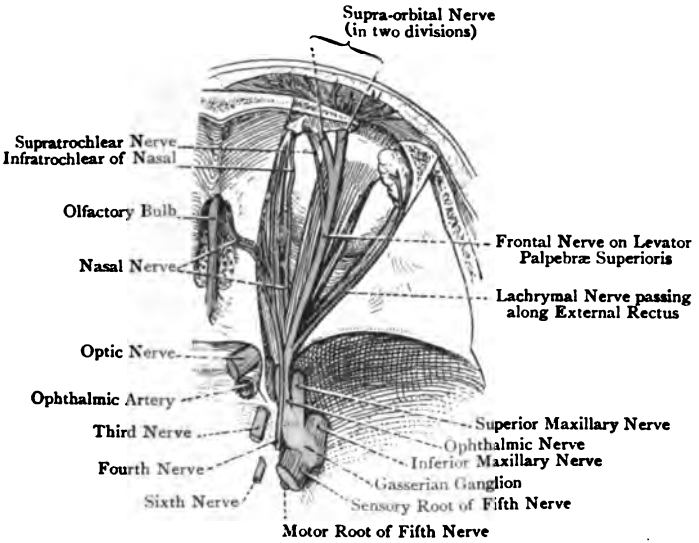


FIG. 453.—DISSECTION OF THE ORBIT FROM ABOVE (HIRSCHFELD AND LEVEILLÉ).

The **nasal nerve** is more deeply placed than the frontal and lachrymal. It enters the orbit through the sphenoidal fissure, and passes between the two heads of the external rectus muscle, lying between the upper and lower divisions of the third nerve. It then passes obliquely inwards and forwards to the inner wall of the orbit, lying beneath the superior rectus and above the optic nerve, and subsequently between the superior oblique and the internal rectus. Having reached the inner wall of the orbit at the anterior ethmoidal, or internal orbital, foramen it parts with its infratrochlear branch, and then passes through that foramen, in company with the anterior ethmoidal artery, and so enters the anterior fossa of the base of the skull. It then passes forwards and inwards in a groove on the upper surface of the cribriform plate of the ethmoid bone,

lying under cover of the dura mater. Having reached the nasal slit at the side of the fore part of the crista galli, it descends through this slit into the nasal fossa, and immediately gives off a *septal branch*. Thereafter the nerve descends in a groove on the posterior surface of the nasal bone, furnishing offsets to the mucous membrane of the outer wall of the nasal fossa, in front of the superior and middle conchæ. Finally, the nerve emerges between the lower border of the nasal bone and the upper lateral nasal cartilage, and descends beneath the compressor naris muscle to supply the skin of the tip and lower part of the side of the nose.

In connection with this remarkable course of the nerve it is to be noted that it is to be met with in four different regions, namely, (1) in the orbit; (2) on the cribriform plate of the ethmoid bone in the anterior cranial fossa; (3) in the nasal fossa; and (4) on the face, in the region of the tip of the nose.

Branches.—The *ganglionic branch* forms the long or sensory root of the lenticular ganglion. It is slender, about ½ inch long, and arises from the nasal as it passes between the two heads of the external rectus. It enters the ciliary ganglion at its postero-superior angle.

The *long ciliary nerves*, usually two in number, arise from the nasal immediately after it has crossed the optic nerve, and they communicate with the short ciliary nerves from the ciliary ganglion, which they accompany to the back part of the sclerotic. Here they pierce the sclerotic, and are distributed along with the short ciliary nerves.

The *infratrochlear nerve* arises from the nasal close to the anterior ethmoidal foramen, and passes forwards beneath the superior oblique muscle. Near the pulley of that muscle it receives a twig from the supratrochlear nerve, and then, passing beneath the pulley, it emerges from the orbit at the inner canthus to be distributed to the skin and conjunctiva of the inner parts of the eyelids, the side of the root of the nose, the lachrymal sac, and the caruncula lacrimalis.

As the nerve traverses the anterior ethmoidal canal it furnishes twigs to the mucous membrane of the frontal air-sinus and of the anterior ethmoidal cells.

A *spheno-ethmoidal* or *posterior ethmoidal branch* is described as passing through the posterior ethmoidal canal to supply the mucous membrane of the posterior ethmoidal cells and of the sphenoidal air-sinus.

For the branches of the nasal nerve to the exterior of the nose and to the nasal fossa, see p. 1101 and 1179.

Ciliary, Lenticular, or **Ophthalmic Ganglion.**—This is a small quadrilateral body, about the size of a moderately large pin-head, which is situated in the posterior part of the orbit, where it lies flattened upon the outer side of the optic nerve. It is usually in close contact with that nerve, and is recognised by its reddish-pink colour. Posteriorly it receives its three roots, and anteriorly the

short ciliary nerves pass forwards from it. The roots are called long, short, and middle. The **long** or **sensory root** is derived from the nasal nerve as it passes between the two heads of the external rectus. It is slender, about ½ inch long, and enters the postero-superior angle of the ganglion. The **short** or **motor root** is derived from the long branch of the lower division of the third nerve which supplies the inferior oblique muscle, and it enters the postero-inferior angle of the ganglion. The **middle** or **sympathetic root**

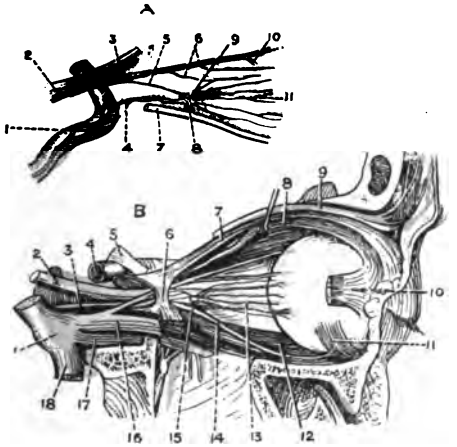


FIG. 454.—A, THE CILIARY GANGLION; B, THE NERVES OF THE ORBIT (EXTERNAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

A

1. Cavernous Plexus
2. Ophthalmic Nerve
3. Nasal Nerve
4. Sympathetic Root of Ciliary Ganglion
5. Sensory Root of Ciliary Ganglion
6. Long Ciliary Nerves
7. Branch of Third Nerve to Inferior Oblique
8. Motor Root of Ciliary Ganglion
9. Ciliary Ganglion
10. Infratrochlear Branch of Nasal Nerve
11. Short Ciliary Nerves

B

1. Gasserian Ganglion
2. Third Nerve
3. Sixth Nerve
4. Internal Carotid Artery
5. Optic Nerve
6. Fibrous Ring for Recti
7. Levator Palpebræ Superioris
8. Superior Rectus
9. Frontal Nerve
10. External Rectus
11. Inferior Oblique
12. Inferior Rectus
13. Short Ciliary Nerves
14. Branch of Third Nerve to Inferior Oblique
15. Ciliary Ganglion
16. Ophthalmic Nerve
17. Superior Maxillary Nerve
18. Inferior Maxillary Nerve

is a very minute nerve which is derived from the cavernous plexus of the sympathetic, and it usually reaches the ganglion in company with the long root. It may, however, join the ganglion separately, and then it does so in close proximity to the entrance of the long root.

The **branches** of the ciliary ganglion are called the *short ciliary nerves*. They are from six to eight in number, and come off, in two groups, from the antero-superior and antero-inferior angles. The

nerves of the lower group usually exceed those of the upper in number. As they pass forward above and below the optic nerve they divide, and give rise to from sixteen to twenty delicate filaments. Having reached the back of the eyeball, they pierce the sclerotic around the entrance of the optic nerve. They then pass forwards between the sclerotic and the choroid, giving twigs to the latter, and they are finally distributed to the ciliary muscle, the iris, and the cornea. The short ciliary nerves thus convey to the eyeball sensory fibres from the ophthalmic division of the fifth nerve, motor fibres from the third nerve, and sympathetic fibres from the cavernous plexus of the sympathetic.

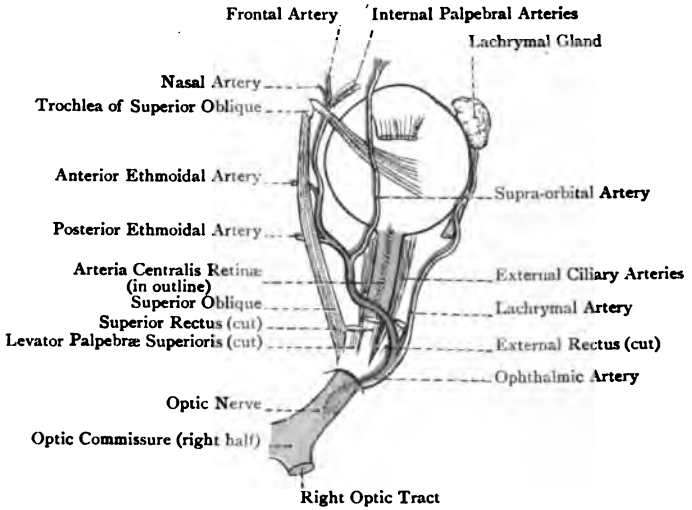


FIG. 455.—DISSECTION OF THE RIGHT ORBIT FROM ABOVE, SHOWING THE OPTIC NERVE, OPHTHALMIC ARTERY, AND SUPERIOR OBLIQUE MUSCLE.

Summary of the Ophthalmic Nerve.—This nerve is entirely sensory. It supplies (1) the skin of (*a*) the frontal region and top of the skull, (*b*) the upper eyelid, and (*c*) the root, tip, and lower part of the side of the nose; (2) the caruncula lacrimalis and lachrymal sac; (3) the mucous membrane of the nasal fossa, and the palpebral conjunctiva; (4) the eyeball; and (5) the lachrymal gland.

Summary of the Ciliary Ganglion.—The branches of this ganglion supply the cornea, iris, and ciliary muscle. The fibres which supply the **sphincter pupillæ** are derived from the *third* or *oculo-motor nerve*, through means of the motor root of the ganglion. The fibres which supply the **dilator pupillæ** are derived from the *sympathetic*, through means of the sympathetic root of the ganglion, which is derived from the cavernous sympathetic plexus.

Branch of the Superior Maxillary Division of the Fifth.—The **orbital** or **temporo-malar nerve**, of small size, arises from the superior maxillary in the spheno-maxillary fossa. It enters the orbit through the spheno-maxillary fissure, and soon divides into two

branches, temporal and malar. The *temporal branch* ascends upon the outer wall of the orbit, and, having received a communicating twig from the lachrymal nerve, it leaves the cavity by passing through the temporal canal in the malar bone. Its destination is the skin of the anterior part of the temporal region.

The *malar branch* passes forwards in the angle between the outer wall and floor of the orbit, and leaves the cavity by passing through the malar canal, from which it subsequently emerges through the malar foramen. It is distributed to the skin over the malar bone.

Ophthalmic Artery.—This vessel arises from the internal carotid artery on the inner aspect of the anterior clinoid process, and it enters the orbit through the optic foramen, lying beneath the optic nerve. Within the orbit it is situated for a short distance on the outer side of the optic nerve, and then it passes obliquely inwards and forwards in a tortuous manner over the nerve to the inner wall of the orbit. Thereafter it passes forwards to the region of the internal angular process of the frontal bone, near which it divides into its two terminal branches, nasal and frontal.

Branches.—These are as follows :

1. Arteria centralis retinæ.
2. Posterior ciliary.
3. Lachrymal.
4. Muscular.
5. Supra-orbital.
6. Posterior ethmoidal.
7. Anterior ethmoidal.
8. Palpebral (two).
9. Nasal.
10. Frontal.

The **arteria centralis retinæ** arises from the ophthalmic at the back part of the orbit below the optic nerve. Its direction is forwards beneath the nerve, and, at a point about ½ inch behind the eyeball, it enters the nerve, and passes forwards in its centre to the retina, upon which it ramifies.

The **posterior ciliary arteries** arise from the ophthalmic whilst it is below the optic nerve. They are arranged in two sets, external and internal, which pass forwards on either side of the optic nerve to the back part of the eyeball. Here they pierce the sclerotic, and the majority of them enter the choroid coat under the name of the *short ciliary arteries*. Two of them, however, are fairly large, and are known as the *long ciliary arteries*. They pass forwards between the sclerotic and the choroid, one on each side, and are distributed to the ciliary muscle and iris.

The **lachrymal artery** arises from the ophthalmic on the outer side of the optic nerve, and passes forwards along the upper border of the external rectus muscle to the lachrymal gland. In its course it furnishes the following branches : (1) a recurrent meningeal branch, which passes through the outer part of the sphenoidal fissure to the middle cranial fossa, where it anastomoses with the middle meningeal artery ; (2) muscular and anterior ciliary branches, the latter piercing the sclerotic very near the corneal margin ;

(3) temporal and malar offsets, which pass through the temporal and malar canals of the malar bone to the face and temporal region, in company with the temporal and malar branches of the temporo-malar or orbital nerve ; (4) two external palpebral arteries, superior and inferior, which pass inwards in the upper and lower eyelids, and anastomose with the internal palpebral branches of the ophthalmic, thus forming arterial arches ; and (5) glandular branches to the lachrymal gland.

The **muscular branches** arise from the ophthalmic in two sets, outer and inner, and also from some of its branches, *e.g.*, the lachrymal and supra-orbital. They furnish a few of the anterior ciliary arteries.

The **supra-orbital artery** arises from the ophthalmic as it crosses

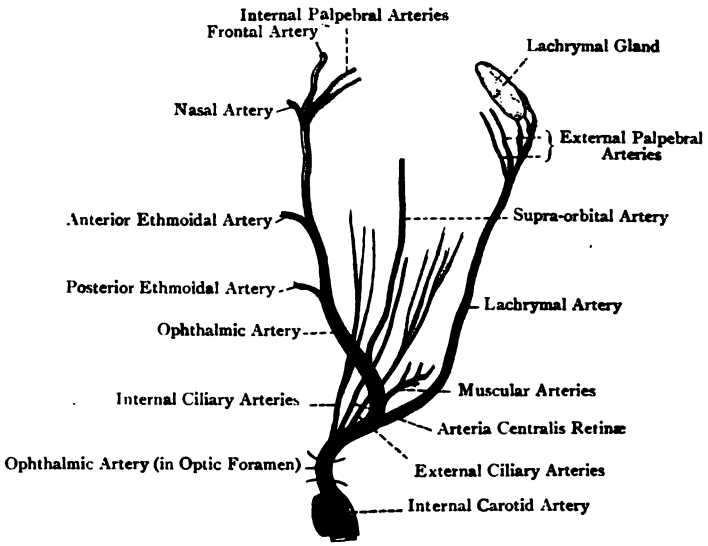


FIG. 456.—DIAGRAM OF THE OPHTHALMIC ARTERY AND ITS BRANCHES.

inwards over the optic nerve. It courses forwards to the supra-orbital notch, through which it passes, with the corresponding nerve, to the forehead. It supplies the upper eyelid and the frontal region, and anastomoses with the superficial temporal and frontal arteries.

The **posterior ethmoidal artery,** a small vessel, passes through the posterior ethmoidal canal on the inner wall of the orbit, and is distributed to the mucous membrane of the posterior ethmoidal cells, and the mucous membrane of the upper and back part of the outer wall of the nasal fossa. The latter branches pass through foramina in the cribriform plate.

The **anterior ethmoidal artery** is larger than the preceding. It

passes through the anterior ethmoidal canal along with the nasal nerve, and enters the anterior fossa of the base of the skull. Here it crosses the cribriform plate of the ethmoid bone to the nasal slit by the side of the crista galli. It then descends through this slit, still in company with the nasal nerve, traverses the nasal groove on the posterior surface of the nasal bone, and finally emerges between the lower border of the nasal bone and the upper lateral nasal cartilage to the tip of the nose. Its branches supply the dura mater in the anterior cranial fossa, the mucous membrane of the anterior ethmoidal cells and corresponding frontal sinus, the mucous membrane of the upper and anterior parts of the nasal fossa, and the skin of the tip of the nose.

The **palpebral arteries** (internal) are two in number, superior and inferior, and are distributed to the eyelids. They arise, separately or conjointly, from the ophthalmic close to the pulley of the superior oblique muscle, and each takes an outward course in the corresponding eyelid. They anastomose with the superior and inferior palpebral branches of the lachrymal artery, thus forming arterial arches.

The **nasal artery** is one of the terminal branches of the ophthalmic. It emerges from the orbit above the internal tarsal ligament, and is distributed to the upper part of the side of the nose in the region of the root, where it anastomoses with the angular and lateral nasal branches of the facial artery.

The **frontal artery** is the other terminal branch of the ophthalmic. It emerges from the orbit at the inner angle, and then ascends to the frontal region, along with the supratrochlear nerve, to be distributed to the integument by the side of the median line. It anastomoses with the supra-orbital artery and its fellow of the opposite side.

Ophthalmic Veins.—These are two in number, superior and inferior. The **superior ophthalmic vein,** of large size, commences at the inner angle of the orbit, where it communicates freely with the angular vein, which is the commencement of the facial vein. It accompanies the ophthalmic artery, passing outwards and backwards over the optic nerve. Having reached the inner end of the sphenoidal fissure, the vessel passes between the two heads of the external rectus muscle, and through the fissure, after which it opens into the anterior part of the cavernous sinus. Its tributaries correspond for the most part to the branches of the ophthalmic artery. It does not, however, receive the frontal vein, nor the supra-orbital vein, but it is in communication with the latter by means of a small branch through the supra-orbital foramen. The **inferior ophthalmic vein** arises in connection with the lower posterior ciliary and lower muscular veins. It passes backwards along the floor of the orbit, and, as a rule, it joins the superior ophthalmic vein before that vessel passes between the two heads of the external rectus, thus giving rise to what is known as the **common ophthalmic vein.** It may, however, leave the orbit separately and open independently into the anterior part of the cavernous sinus. It com-

municates freely with the pterygoid plexus of veins through the spheno-maxillary fissure, and that plexus sometimes represents its mode of termination.

Structures passing through the Sphenoidal Fissure.—These structures are as follows:

1. The third nerve.
2. The fourth nerve.
3. The nasal, lachrymal, and frontal nerves.
4. The sixth nerve.
5. The sympathetic root of the ciliary ganglion.
6. The two ophthalmic veins.
7. The orbital branch of the middle meningeal artery.
8. The recurrent branch of the lachrymal artery.
9. A process of the dura mater.

The lachrymal, frontal, and fourth nerves enter the orbit above the external rectus muscle, in the order named from without inwards.

The third nerve, the nasal nerve, and the sixth nerve enter the orbit between the two heads of the external rectus muscle, the third

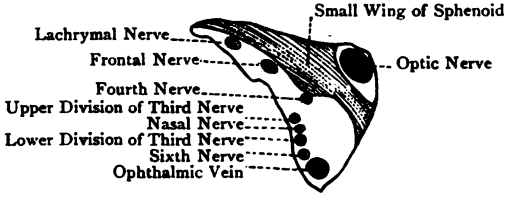


FIG. 457.—DIAGRAM OF THE LEFT SPHENOIDAL FISSURE, SHOWING THE TRANSMITTED STRUCTURES (POSTERIOR VIEW).

nerve having previously broken up into two divisions; and the two ophthalmic veins leave the orbit between the two heads of the external rectus. The order of parts between the two heads of the external rectus, from above downwards, is as follows:

1. The superior division of the third nerve.
2. The nasal nerve.
3. The inferior division of the third nerve.
4. The sixth nerve.
5. The ophthalmic veins (or vein).

The sympathetic root of the ciliary ganglion passes through the sphenoidal fissure independently, or along with the nasal nerve, or sometimes with the third nerve.

THE FACE.

Landmarks.—The nasal eminence or glabella of the frontal bone can be felt just above the root of the nose, and extending outwards from it on either side is the superciliary ridge, behind the inner part of which is the corresponding frontal air-sinus. Below the superciliary ridge the supra-orbital arch can readily be felt, and at the junction of its inner third and outer two-thirds is the supra-orbital notch, or foramen, for the passage of the supra-orbital nerve and artery. A line drawn from the position of the supra-orbital notch to the base of the inferior maxilla, in such a manner as to pass between the lower bicuspid teeth, crosses in succession the infra-orbital and mental foramina. The infra-orbital foramen lies in this line at a point about ¼ inch below the infra-orbital margin, and it indicates the exit of the infra-orbital nerve and artery from the infra-orbital canal. The mental foramen in the adult lies midway between the alveolar and basilar borders of the inferior maxilla, and it indicates the exit of the mental nerve and artery from the inferior dental canal.

In line with the tragus of the auricle the zygomatic arch can be felt, and leading backwards from it above the orifice of the meatus auditorius externus is the posterior root of the zygoma. This root is continued into the supramastoid crest, which corresponds to the level of the tegmen antri. In connection with the supramastoid crest it is important to note the position of the suprameatal triangle of Macewen. This triangle is bounded above by the supramastoid crest, below by the postero-superior part of the meatus auditorius externus, and behind by a vertical line connecting the upper and lower boundaries, this line being continuous with the posterior part of the meatus auditorius externus.

The superficial temporal artery and auriculo-temporal nerve lie directly in front of the tragus, the division of the artery into its anterior and posterior branches taking place about the level of the upper part of the auricle. The anterior branch of the artery lies nearly an inch above the external angular process of the frontal bone, and the posterior branch about an inch above the upper part of the auricle.

The parotid gland is situated in front of the auricle. It is limited above by the zygoma, behind by the auricle, and inferiorly it extends for a limited distance into the digastric triangle of the neck. Anteriorly it extends for a short distance over the masseter muscle, and Stensen's duct issues from its anterior border. The course of this duct may be indicated by a line drawn from the incisura intertragica, or from the junction of the lobule and cartilage of the auricle, to a point midway between the nostril and the red margin of the upper lip. About the middle third of this line corresponds to the duct. Above it is the transverse facial artery, and below it are the infra-orbital branches of the facial nerve. The course of the

facial nerve through the parotid gland may be indicated by a line drawn forwards from the lobule of the auricle parallel to the line indicating the course of Stensen's duct.

The posterior border of the ramus of the inferior maxilla can readily be felt. It leads superiorly to the condyle and temporomandibular joint, and inferiorly to the angle of the bone. Extending forwards from the angle is the basilar border, which, about 2 inches from the angle, supports the facial artery, pulsation being readily felt, during life, in this part of the vessel, in front of the masseter muscle, the facial vein intervening between the two. In this situation a lymphatic gland lies in contact with the artery. From this point the facial artery extends, in a tortuous manner, to the inner canthus of the eye, passing close to the angle of the mouth, the facial vein pursuing a comparatively straight course.

In the median line of the face the structures to be noted are the nasal bones, nasal cartilages, dorsum and tip of the nose, alæ nasi, columella nasi, and the philtrum, which latter is the median groove leading from the columella nasi to the upper lip.

For the component parts of the auricle, see p. 1114.

The palpebræ or eyelids are to be noted, along with the palpebral fissure between them, and the canthi, outer and inner, at either extremity. The tarsal plates of the upper and lower eyelids can easily be felt, and connected with their inner extremities is the internal tarsal ligament, or tendo oculi. This latter may be made tense by approximating the eyelids, and drawing them outwards. It crosses the lachrymal sac a little above the centre. The eyelids being everted, the outlines of the Meibomian glands may be seen, these being arranged in a linear manner, and being placed perpendicular to the palpebral margins. The eyelashes, or cilia, on the margins of the eyelids are to be noted, and within these are the orifices of the ducts of the Meibomian glands, which are arranged in a row. Along the line of the eyelashes the skin of the eyelid becomes continuous with the palpebral conjunctiva, and along the line of reflection of the palpebral conjunctiva on to the eyeball the recess, known as the fornix, is to be noted. At the inner canthus, where the eyelids do not meet, there is a recess between the lids and the eyeball, which lodges a small red fleshy protuberance, called the caruncula lacrimalis, which is provided with a few delicate hairs. In this situation there is the fold called the plica semilunaris. Upon the eyelids at their inner ends the papillæ lacrimales are visible, and on each papilla is a minute orifice, called the punctum lacrimale. The lower papilla is larger than the upper, and is placed a little farther out. Each punctum leads into the lachrymal canal, and by these canals the tears are conveyed into the lachrymal sac, and thence by the nasal duct into the inferior meatus of the nose. The position of the lachrymal sac may be indicated by drawing the eyelids outwards, so as to render tense the tendo oculi, which, as stated, crosses the sac a little above its centre.

Muscles of the Face.

Orbicularis Palpebrarum—Orbital Portion—*Origin.*—(1) The inner part of the internal tarsal ligament; (2) the outer surface of the nasal process of the superior maxilla; and (3) the internal angular process of the frontal bone.

Insertion.—This corresponds to the origin, there being no attachment to the outer part of the orbit.

Palpebral Portion—*Origin.*—The upper and lower surfaces of the internal tarsal ligament.

Insertion.—The upper and lower surfaces of the external tarsal ligament.

Nerve-supply.—The facial nerve.

Action—**Orbital Portion.**—(1) The upper half depresses the eyebrow, and antagonizes the frontalis muscle; (2) the lower half elevates the skin of the infra-orbital region. **Palpebral Portion.**—This closes the eyelids, as in winking, the upper lid being depressed and the lower raised, the former movement being more free than the latter. Through means of its connection with the internal tarsal ligament the palpebral portion draws forwards the front part of the lachrymal sac, and so contributes to the removal of the tears. When the entire muscle contracts the lids are forcibly closed, and drawn slightly inwards.

The upper part of the muscle is related by its deep surface to the frontalis, the supra-orbital vessels and nerve, and the supratrochlear nerve. The chief deep relations of the lower part are the levator labii superioris, and, beneath that, the infra-orbital nerve.

Internal Tarsal Ligament.—This is also called the *tendo oculi*, or *tendo palpebrarum.* It is attached internally to the outer surface of the nasal process of the superior maxilla, immediately in front of the lachrymal groove. Its direction is outwards in front of the lachrymal sac, and it bifurcates at the inner canthus, the divisions diverging, and taking attachment to the inner extremities of the tarsal plates. As the ligament passes in front of the lachrymal sac it is in intimate contact with that sac, and it gives origin to the palpebral portion of the orbicularis palpebrarum, which explains the action of that portion of the muscle upon the lachrymal sac.

External Tarsal Ligament.—This is attached externally to the frontal process of the malar bone. Its direction is inwards, and it bifurcates at the outer canthus, the divisions taking attachment to the outer extremities of the tarsal plates.

Tensor Tarsi (*Muscle of Horner*)—*Origin.*—The crest of the lachrymal bone, behind the lachrymal sac.

Insertion.—By means of two slips into the inner extremities of the tarsal plates, where the fibres become continuous with the ciliary fibres of the orbicularis palpebrarum.

Nerve-supply.—The facial nerve.

The direction of the muscle is outwards and forwards, and its two slips pass behind the lachrymal canals.

Action.—To draw backwards the outer part of the internal tarsal ligament, and in this manner compress the lachrymal sac, the effect of which is to propel the tears into the nasal duct.

Corrugator Supercilii—*Origin.*—The inner extremity of the superciliary ridge of the frontal bone.

Insertion.—The deep surface of the skin of the eyebrow at the centre.

Nerve-supply.—The facial nerve.

The direction of the muscle is outwards and upwards, and to reach the skin the fibres pass through the upper part of the orbicularis palpebrarum and the adjacent portion of the frontalis.

Action.—To draw the skin of the eyebrow inwards and downwards, giving rise to vertical wrinkles between the eyebrows, as in frowning.

The muscle is under cover of the inner portion of the upper half of the orbicularis palpebrarum, and it conceals the supratrochlear nerve as it emerges from the orbit.

Muscles of the Nose—Pyramidalis Nasi—*Origin.*—The aponeurosis of the compressor naris over the lower part of the nasal bone.

Insertion.—The deep surface of the skin over the glabella of the frontal bone. Some of the fibres become continuous with the mesial portion of the frontalis.

Nerve-supply.—The facial nerve.

Action.—To draw downwards the skin between the eyebrows, giving rise to transverse wrinkles.

Compressor Naris—*Origin.*—The superior maxilla between the canine fossa and the nasal notch.

Insertion.—By means of an expanded aponeurosis which blends with its fellow of the opposite side over the cartilaginous portion of the nose, and gives origin superiorly to the pyramidalis nasi.

Nerve-supply.—The facial nerve.

Action.—To depress the cartilaginous portion of the nose.

The muscle is triangular, and at its origin is under cover of the levator labii superioris alæque nasi.

Levator Labii Superioris Alæque Nasi — *Origin.* — The outer surface of the nasal process of the superior maxilla by a pointed extremity.

Insertion.—By means of two slips. The **inner** or **nasal slip** is inserted into the skin of the ala of the nose. The **outer** or **labial slip** is inserted into the skin of the upper lip, some of its fibres blending with the levator labii superioris, and others with the upper part of the orbicularis oris.

Nerve-supply.—The facial nerve.

Action.—(1) To raise the upper lip, and (2) to raise, and dilate, the ala of the nose.

The muscle is triangular, and covers the origin of the compressor naris.

Depressor Alæ Nasi—*Origin.*—The incisor fossa of the superior maxilla.

Insertion.—The posterior part of the ala, and the adjacent part of the septum, of the nose.

Nerve-supply.—The facial nerve.

Action.—To depress the ala of the nose.

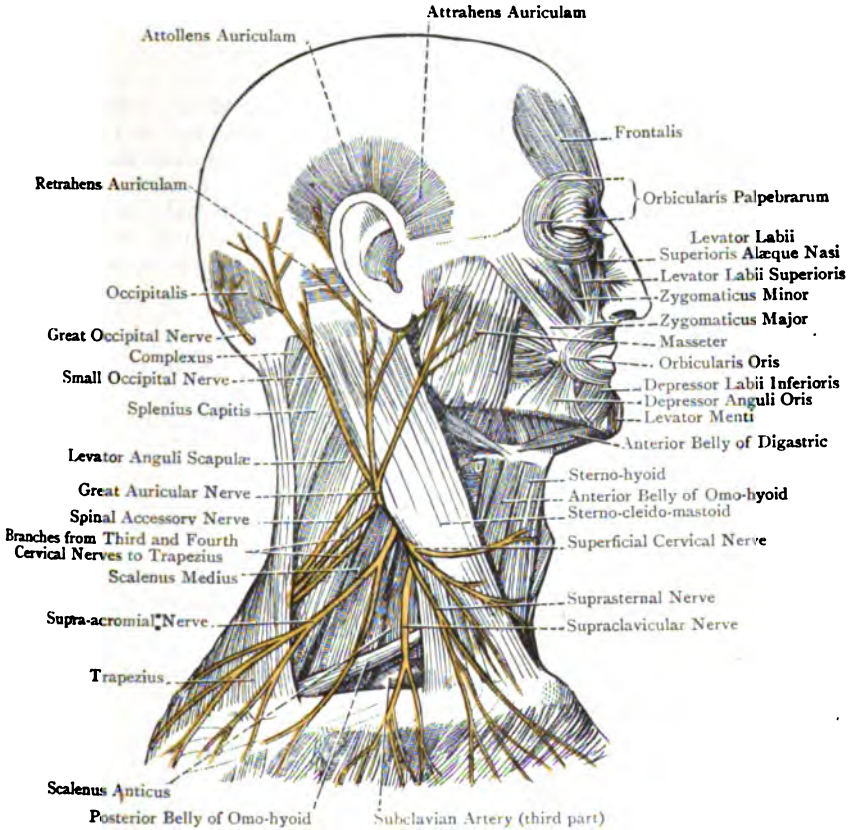


FIG. 458.—THE RIGHT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed, and the Nerves are shown).

Dilator Naris Anterior—*Origin.*—The cartilage of the aperture of the nose.

Insertion.—The deep surface of the skin over the ala of the nose.

Nerve-supply.—The facial nerve.

Action.—To dilate the nostril.

Dilator Naris Posterior—*Origin.*—(1) The margin of the nasal notch of the superior maxilla; and (2) the accessory or sesamoid cartilages of the nose.

Insertion.—The skin over the back part of the ala of the nose.

Nerve-supply.—The facial nerve.

Action.—To dilate the nostril.

Levator Labii Superioris—*Origin.*—The superior maxilla between the infra-orbital foramen and the lower margin of the orbit.

Insertion.—The skin of the upper lip.

Nerve-supply.—The facial nerve.

Action.—To raise the upper lip.

The muscle is quadrilateral. At its origin it is overlapped by the lower half of the orbicularis palpebrarum, and it covers the infra-orbital nerve and artery as they emerge from the infra-orbital foramen. At its insertion the fibres interlace with those of the upper half of the orbicularis oris. Its inner border is joined by some of the fibres of the outer or labial slip of the levator labii superioris alæque nasi, and its outer border is joined by some fibres of the zygomaticus minor.

Levator Anguli Oris—*Origin.*—The upper part of the canine fossa of the superior maxilla, under cover of the levator labii superioris.

Insertion.—The angle of the mouth, where some of the fibres are inserted into the skin, whilst others decussate with those of the depressor anguli oris, and enter the lower lip, mingling with those of the lower half of the orbicularis oris.

Nerve-supply.—The facial nerve.

The direction of the muscle is downwards and slightly outwards.

Action.—To raise the angle of the mouth, and at the same time to draw it slightly inwards.

The infra-orbital nerve and artery are superficial to the muscle.

Zygomaticus Minor—*Origin.*—The anterior and lower part of the malar bone, close to the superior maxilla.

Insertion.—The skin of the upper lip immediately external to the levator labii superioris, with the outer border of which muscle some of its fibres blend.

Nerve-supply.—The facial nerve.

The muscle is directed downwards and inwards.

Action.—To raise feebly the upper lip, and at the same time to draw it slightly outwards.

Zygomaticus Major—*Origin.*—The outer surface of the malar bone near the zygomatic suture.

Insertion.—The skin at the angle of the mouth, where its fibres blend with those of the orbicularis oris.

Nerve-supply.—The facial nerve.

The muscle is directed downwards and inwards.

Action.—To draw the angle of the mouth upwards and outwards.

Risorius of Santorini—*Origin.*—The deep fascia which covers the masseter muscle and parotid gland.

Insertion.—The skin at the angle of the mouth, where its fibres blend with the orbicularis oris.

Nerve-supply.—The facial nerve.

The direction of the muscle is inwards, some of its fasciculi also ascending.

Action.—To draw the angle of the mouth outwards and slightly downwards. It is not a muscle of laughter, but is expressive of scorn or pain.

The muscle consists of a few scattered fasciculi, which are embedded in the adipose tissue over the buccinator, and it is to be regarded as a detached portion of the platysma myoides.

Buccinator—*Origin.*—(1) The outer surfaces of the alveolar borders of the superior and inferior maxillæ, opposite the three molar alveoli ; and (2) the anterior aspect of the pterygo-mandibular ligament.

Insertion.—The orbicularis oris at the angle of the mouth.

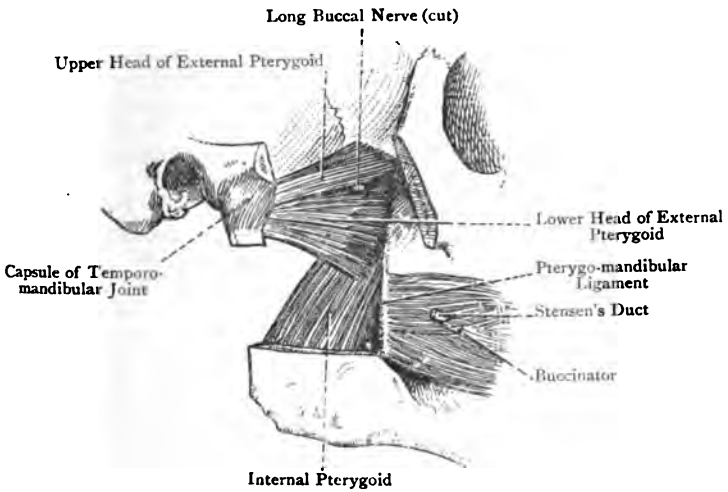


FIG. 459.—THE PTERYGOID AND BUCCINATOR MUSCLES.

The central fibres decussate, those from above entering the lower lip, and those from below entering the upper lip. The highest and lowest fibres take no part in this decussation, the highest passing directly into the upper lip, and the lowest into the lower lip.

Nerve-supply.—The short buccal nerves, which are derived from (1) the infra-orbital branches of the temporo-facial division of the facial, and (2) the buccal branches of the cervico-facial division of the facial, nerve.

Action.—(1) To draw the angle of the mouth outwards, and press the lips against the teeth, thus preventing the food from accumulating between the lips and the teeth during mastication ; and (2) to regulate the expulsion of air from the buccal cavity when the buccal aperture is narrowed, as in playing the flute, or in whistling.

The muscle is expanded over the cheek, but towards the angle

of the mouth it becomes narrow and thick. It is pierced by Stensen's duct opposite the second upper molar tooth, and the long buccal nerve also passes through it on its way to the mucous membrane of the cheek. Externally the muscle is overlapped by the anterior border of the masseter, from which it is separated by the buccal pad of fat.

Buccal Pad of Fat.—This is a well-defined collection of fat which is situated upon the buccinator muscle close to the anterior border of the masseter. It is continuous with the fat of the zygomatic fossa, and is well developed in young children.

Depressor Anguli Oris (*triangularis menti*)—*Origin.*—The external oblique line of the inferior maxilla, from about the level of the canine alveolus to about the level of the first molar alveolus.

Insertion.—The angle of the mouth, where some of the fibres are attached to the skin, whilst others decussate with those of the levator anguli oris and enter the upper lip, in which they mingle with the upper part of the orbicularis oris.

Nerve-supply.—The facial nerve.

Action.—To depress the angle of the mouth.

Internally the muscle overlaps a portion of the depressor labii inferioris.

Depressor Labii Inferioris (*quadratus menti*)—*Origin.*—The lower part of the outer surface of the body of the inferior maxilla, commencing almost close to the symphysis, and extending outwards to a point just below the mental foramen.

Insertion.—The skin of the lower lip.

Nerve-supply.—The facial nerve.

The muscle is directed upwards and inwards.

Action.—To draw the lower lip downwards and slightly outwards.

The muscle is overlapped externally by a portion of the depressor anguli oris, and internally it is in contact superiorly with its fellow of the opposite side. The deep surface is related externally to the mental foramen and the mental nerve and vessels, and internally to part of the levator menti. In the lower lip its fibres pass amongst those of the lower part of the orbicularis oris.

Levator Menti, or **Levator Labii Inferioris**—*Origin.*—The incisor fossa of the inferior maxilla.

Insertion.—The skin of the chin.

Nerve-supply.—The facial nerve.

The muscle is directed downwards and forwards.

Action.—(1) To raise the integument of the chin ; and (2) to elevate and protrude the lower lip. It gives rise to a proud or imperious expression, and has been hence called the *musculus superbus.*

Superiorly the muscle is under cover of the depressor labii inferioris. Inferiorly it appears along with its fellow, between the two depressor labii inferioris muscles.

Orbicularis Oris.—This is a complex muscle, being composed of three strata. The *superficial stratum* consists of fibres which are prolonged from the elevators and depressors of the angles of the

mouth, and extend as far as the centre of the lip, but are not continuous with those of the opposite half. They are *inserted* into the skin, and are partially reinforced by fibres from the elevators of the upper lip, the zygomatic muscles, the risorius, the posterior fibres of the platysma myoides, and the depressor labii inferioris.

The *intermediate stratum* consists of fibres which are derived from the buccinator muscles. These fibres are disposed transversely, and those of opposite sides are directly continuous. The fibres of this stratum extend quite to the margins of the lips.

The foregoing fibres are destitute of bony and cartilaginous attachments.

The *deepest stratum* consists of fibres which are so disposed as to constitute specially-named muscles. These are four in number for the upper lip, two for each half, namely, the musculus incisivus superior and the musculus naso-labialis ; and two for the lower lip, one for each half, namely, the musculus incisivus inferior.

The **musculus incisivus superior** arises from the incisor fossa of the superior maxilla, and turns outwards in the upper lip towards the angle of the mouth, where the fibres blend with the orbicularis oris. The **musculus naso-labialis** arises from the back part of the nasal septum, and, like the preceding, turns outwards in the upper lip to blend with the orbicularis oris. The **musculus incisivus inferior** arises from the incisor fossa of the inferior maxilla, and turns outwards in the lower lip towards the angle of the mouth, where the fibres blend with the orbicularis oris. In addition to the foregoing fibres there are oblique fibres which extend between the skin and the mucous membrane.

Nerve-supply.—The facial nerve.

Action.—(1) To close the oral aperture ; and (2) to press the lips against the alveolar margins.

The muscle is not a sphincter muscle, properly so called, inasmuch as the upper and lower fibres are not directly continuous at the angles of the mouth. It is separated from the buccal mucous membrane by the coronary arteries and the labial mucous glands.

The **labial mucous glands,** which are racemose, or acino-tubular, are numerous, and each is about the size of a small pea. They are situated on the deep surface of the mucous membrane of the lips, where they lie in the loose areolar tissue between the mucous membrane and the orbicularis oris. Their ducts open into the vestibule of the mouth.

The **buccal mucous glands,** also racemose, or acino-tubular, are situated between the mucous membrane of the cheek and the buccinator.

The **molar mucous glands,** also racemose, or acino-tubular, lie upon the buccinator in the vicinity of the terminal part of Stensen's duct. They are four or five in number, and their ducts, having pierced the buccinator, open into the vestibule of the mouth opposite the molar teeth.

Nerves of the Face.

The nerves of the face are thirteen in number on either side. Twelve of these are sensory nerves, and one is motor, namely, the facial nerve.

The **facial** or **seventh cranial nerve** (*portio dura*) will only be described here after its emergence from the aqueduct of Fallopius in the petrous part of the temporal bone. It emerges from that

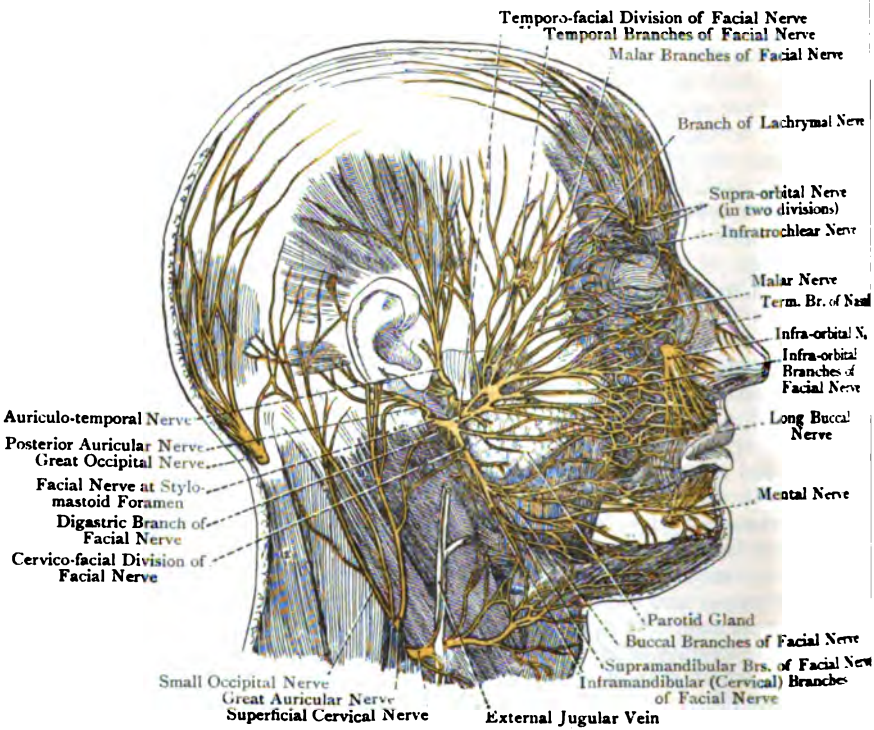


FIG. 460.—SUPERFICIAL DISSECTION OF THE RIGHT SIDE OF THE HEAD AND UPPER PART OF THE NECK (HIRSCHFELD AND LEVEILLÉ).

1, Sterno-cleido-mastoid ; 2, Trapezius.

aqueduct through the stylo-mastoid foramen, after which it passes downwards and then forwards into the parotid gland. Near the posterior border of the ramus of the inferior maxilla it breaks up into two terminal parts, called the temporo-facial and cervico-facial divisions.

Branches.—These are as follows : the posterior auricular, digastric, stylo-hyoid, and the two terminal divisions, namely, temporo-facial, and cervico-facial

The **posterior auricular nerve** arises from the facial close to the stylo-mastoid foramen. It ascends between the auricle and the mastoid process, where it lies deeply, and divides into two branches, auricular and occipital. The *auricular branch* passes upwards behind the auricle and beneath the retrahens auriculam, to be distributed to that muscle, and it may be to the attollens auriculam, as well as to the small intrinsic muscles on the inner aspect of the auricle. The *occipital branch* passes backwards to supply the occipitalis muscle. The posterior auricular nerve communicates with the great auricular, the small occipital, and the auricular branch (Arnold's nerve) of the pneumogastric.

The **digastric nerve** is directed downwards, and breaks up into branches which enter the posterior belly of the digastric muscle. One of the digastric branches communicates with the glosso-pharyngeal nerve.

The **stylo-hyoid nerve** usually arises in common with the preceding. It is of some length, and, passing forwards, it enters the stylo-hyoid muscle about its centre.

The **terminal divisions,** as stated, are called **temporo-facial** and **cervico-facial.** Both divisions continue to pass forwards in the parotid gland, crossing superficially the temporo-maxillary vein and the external carotid artery, the direction of these vessels being vertical. In this part of their course these divisions receive the following branches; the temporo-facial division receives two branches from the auriculo-temporal nerve, and the cervico-facial division receives branches from the great auricular nerve. The temporo-facial division, which is the larger of the two, traverses the upper part of the parotid gland, and the cervico-facial division passes through the gland in a forward and downward direction. Each division breaks up, within the gland, into three branches, and, as these pass in various directions over the face and upper portion of the neck, they ramify freely. The branches frequently communicate with each other in a plexiform manner, both in the parotid gland and on the face, the plexus thus formed being known as the *pes anserinus* or goose's foot. The ramifications also communicate with the branches of the three divisions of the fifth nerve which appear on the face, these being sensory nerves.

The **temporo-facial division** furnishes three sets of branches, namely, temporal, malar, and infra-orbital. The *temporal branches* ascend over the zygomatic arch to the temporal region, and are distributed to the following muscles: the attrahens and attollens auriculam, the intrinsic muscles on the outer surface of the auricle, the frontalis, the upper part of the orbicularis palpebrarum, and the corrugator supercilii. The temporal branches communicate with the supra-orbital and lachrymal branches of the ophthalmic, the temporal branch of the orbital from the superior maxillary, and the auriculo-temporal of the inferior maxillary, all of these being sensory nerves.

The *malar branches* pass forwards over the malar bone towards

the outer angle of the orbit, and supply the outer part of the orbicularis palpebrarum. They form communications with the lachrymal branch of the ophthalmic, with the malar of the orbital, and with the infra-orbital, both these latter being branches of the superior maxillary, and all of them being sensory nerves.

The *infra-orbital branches*, the largest of this group, pass forwards to the region between the lower margin of the orbit and the upper lip. They supply the lower part of the orbicularis palpebrarum,

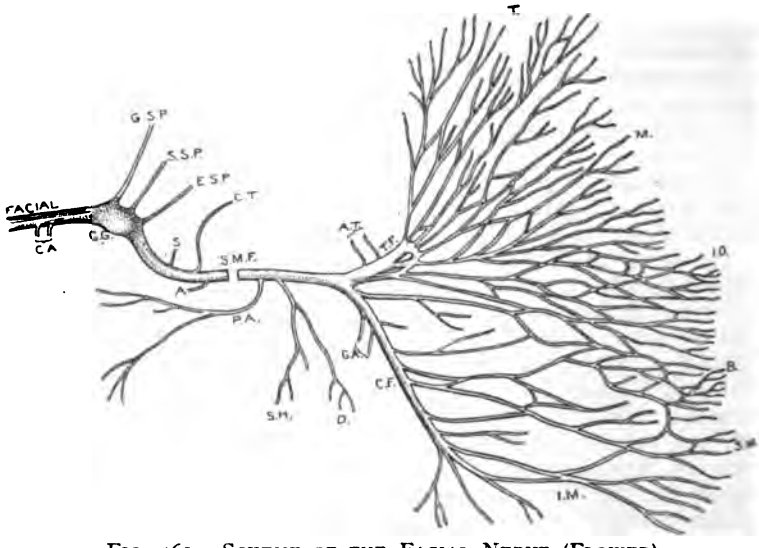


FIG. 461.—SCHEME OF THE FACIAL NERVE (FLOWER).

C.A. Communicating Twigs with Auditory
G.G. Geniculate Ganglion
G.S.P. Great Superficial Petrosal
S.S.P. Branch to Small Superficial Petrosal
E.S.P. External Superficial Petrosal
S. Branch to Stapedius Muscle
C.T. Chorda Tympani
A. Auricular Branch (Arnold's Nerve)
S.M.F. Stylo-mastoid Foramen
P.A. Posterior Auricular
S.H. Branch to Stylo-hyoid Muscle
D. Branch to Posterior Belly of Digastric
A.T. Communicating Branches from Auriculo-temporal
T.F. Temporo-facial Division
T. Temporal Branches
M. Malar Branches
I.O. Infra-orbital Branches
G.A. Communicating Branches from Great Auricular
C.F. Cervico-facial Division
B. Buccal Branches
S.M. Supramandibular Branches
I.M. Inframandibular Branches

the muscles of the nose, the elevators of the upper lip, the upper part of the orbicularis oris, and the buccinator. They communicate with the following sensory nerves: the infra-orbital of the superior maxillary, the infratrochlear of the nasal, and the terminal cutaneous branch of the nasal, from the ophthalmic. The communications with the infra-orbital nerve take place under cover of the levator labii superioris muscle, and form a somewhat intricate plexus, called the *infra-orbital plexus*.

The **cervico-facial division** likewise furnishes three sets of

branches, namely, buccal, supramandibular, and inframandibular or cervical.

The *buccal branches* pass forwards over part of the masseter and the buccinator muscles to the angle of the mouth. They supply the buccinator and the outer part of the orbicularis oris, and are connected with the infra-orbital branches of the temporo-facial division, and with the *long buccal nerve*, which is a branch of the inferior maxillary division of the fifth nerve. The latter communications take the form of a plexus situated on the superficial surface of the buccinator muscle, called the *buccal plexus*.

The *supramandibular branches* pass forwards over the mandible to the region below the lower lip. They supply the lower part of the orbicularis oris, depressor anguli oris, depressor labii inferioris,

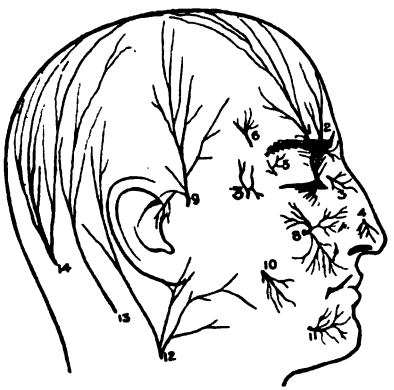


FIG. 462.—DIAGRAM OF THE SENSORY NERVES OF THE RIGHT SIDE OF THE HEAD.

1. Supra-orbital
2. Supratrochlear
3. Infratrochlear
4. Nasal
5. Lachrymal
6. Temporal of Orbital
7. Malar of Orbital
8. Infra-orbital
9. Auriculo-temporal
10. Long Buccal
11. Mental
12. Great Auricular
13. Small Occipital
14. Great Occipital

and levator menti muscles. They communicate with the mental branch of the inferior dental from the inferior maxillary nerve, under cover of the depressor anguli oris.

The *inframandibular* or *cervical branch* descends beneath the upper part of the platysma myoides and the deep cervical fascia to the suprahyoid region. Having pierced the deep fascia, it divides into branches which curve forwards and supply the platysma on its deep surface. It communicates freely with the upper branch of the superficial cervical nerve from the cervical plexus.

Summary of the Facial Nerve.—The facial nerve, after its emergence from the aqueduct of Fallopius through the stylo-mastoid foramen, supplies the following muscles: (1) the extrinsic and intrinsic muscles of the auricle; (2) the posterior belly of the digastric and the stylo-hyoid; (3) the muscles of the scalp, namely, the occipitalis and the frontalis; (4) the superficial

muscles of the face, including the buccinator, but not the masseter, nor the levator palpebræ superioris ; and (5) the platysma myoides. All these muscles, except the posterior belly of the digastric and the stylo-hyoid, are spoken of as muscles of expression. The nerve establishes free communications with all three divisions of the fifth nerve, which are sensory. It also communicates with the small occipital, great auricular, and superficial cervical, which are branches of the cervical plexus.

Sensory Nerves of the Face.—These, as stated, are twelve in number on either side. With one exception they are derived from the fifth cranial (trigeminal or trifacial) nerve, the exception being in the case of the great auricular, which is a branch of the cervical plexus. Most of them reach their distribution as independent nerves, but some sensory fibres reach the skin of the face through their connection with the branches of the facial nerve, as, for example, in the case of the auriculo-temporal and great auricular nerves. The sensory nerves are as follows :

A. Branches of the Fifth Cranial Nerve.

Distal Sources.	Proximate Sources.	Nerves.
1. Ophthalmic nerve.	(*a*) Frontal division.	Supra-orbital.
		Supratrochlear.
	(*b*) Lachrymal division.	Superior palpebral.
	(*c*) Nasal division.	Infratrochlear.
		External terminal branch of nasal.
2. Superior maxillary nerve.	(*a*) Superior maxillary.	Infra-orbital.
	(*b*) Orbital, or Temporo-malar.	Temporal.
		Malar.
3. Inferior maxillary nerve.	(*a*) Anterior division.	Long buccal.
	(*b*) Posterior division.	Auriculo-temporal.
	(*c*) Inferior dental of posterior division.	Mental.

B. Facial Branches of the Great Auricular Nerve.

Branches of the Fifth Cranial Nerve.—The **supra-orbital** and **supratrochlear nerves** have been already described (see p. 992). The former is distributed to the skin of the frontal region and the upper part of the scalp ; and the latter to the skin of the lower and central portion of the frontal region. Both these nerves furnish twigs to the skin of the upper eyelid.

The **superior palpebral branch of the lachrymal nerve** pierces the superior palpebral ligament, and is distributed to the skin and conjunctiva of the outer part of the upper eyelid, as well as to the skin in the immediate vicinity of the external angular process of the frontal bone.

The **infratrochlear branch of the nasal nerve** emerges from the orbit below the pulley of the superior oblique muscle, and furnishes twigs to the skin and conjunctiva of the inner parts of the eyelids,

the side of the root of the nose, the lachrymal sac, and the caruncula lacrimalis.

The **external terminal branch of the nasal nerve** emerges between the lower border of the nasal bone and the upper lateral nasal cartilage, and descends beneath the compressor naris muscle to the tip of the nose. Its twigs supply the skin of the tip, and lower part of the side, of the nose.

The **infra-orbital nerve** is the terminal part of the superior maxillary division of the fifth. It emerges from the infra-orbital canal through the infra-orbital foramen, where it is under cover of the levator labii superioris. In this situation it communicates with the infra-orbital branches of the facial, forming the *infra-orbital plexus*, and it divides into three sets of branches, namely, inferior palpebral, lateral nasal, and superior labial. The *inferior palpebral branches* ascend to supply the skin and conjunctiva of the lower eyelid. The *nasal branches* pass inwards, and are distributed to the skin of the side of the nose. The *superior labial branches*, long and large, descend to supply the skin and mucous membrane of one half of the upper lip. As they descend they furnish twigs to the skin between the infra-orbital foramen and the upper lip.

The **temporal branch of the orbital or temporo-malar** nerve is of small size. Having traversed the temporal canal in the malar bone, it pierces the temporal fascia about 1 inch above the front part of the zygoma, and behind the marginal process on the postero-superior or temporal border of the malar bone, and is distributed to a limited portion of the skin over the anterior part of the temporal region.

The **malar branch of the orbital** or **temporo-malar nerve** is of small size, and emerges from the malar canal in the malar bone through the malar foramen. It is distributed to the skin over the malar bone.

The **long buccal nerve** is a branch of the anterior division of the inferior maxillary nerve. It emerges from beneath the anterior border of the masseter on to the superficial surface of the buccinator, where it divides into branches which communicate freely with the buccal branches of the facial nerve, forming the *buccal plexus*. Its final distribution is to the skin and mucous membrane of the cheek, the branches to the latter piercing the buccinator.

The **auriculo-temporal nerve,** which is a branch of the posterior division of the inferior maxillary nerve, has been already described as regards its cutaneous distribution (see p. 995).

The **mental nerve** is one of the terminal branches of the inferior dental, which, in turn, is a branch of the posterior division of the inferior maxillary nerve. It emerges from the dental canal in the inferior maxilla through the mental foramen, under cover of the depressor anguli oris, and in line with the interval between the two lower bicuspid alveoli. Its branches supply the skin and mucous membrane of one half of the lower lip, and the skin over one half of the body of the inferior maxilla.

The supra-orbital, infra-orbital, and mental nerves, being fre-

quently the seat of neuralgia, their positions for purposes of operative treatment can readily be ascertained in the following manner: A line drawn upwards from the position of the mental foramen, which is in line with the interval between the two lower bicuspid alveoli, to the supra-orbital notch, which is situated at the junction of the outer two-thirds and the inner third of the supra-orbital arch, will coincide with the infra-orbital foramen. This line, therefore, is over the points of emergence of these three important sensory nerves.

Branches of the Great Auricular Nerve.—The facial branches of the great auricular nerve, which is a branch of the cervical plexus, are distributed to the skin over the parotid gland. They send twigs into the gland which communicate with the cervico-facial division of the facial nerve.

Arteries of the Face.

The arteries of the face are as follows:

Sources.	Arteries.	Sources.	Arteries.
External carotid.	Facial.	Superficial temporal.	Transverse facial. Anterior temporal. Orbital.
Ophthalmic, from internal carotid.	Nasal. Frontal. Supra-orbital. Internal palpebral (superior and inferior). Terminal branch of anterior ethmoidal.	Internal maxillary.	Infra-orbital. Buccal.
		Inferior dental, from internal maxillary.	Mental.
Lachrymal, from ophthalmic.	External palpebral (superior and inferior). Temporal. Malar.		

The chief of these arteries are the facial and the transverse facial.

Facial Artery.—The facial artery (*external maxillary*) is one of the three anterior branches of the external carotid, being the highest in order. It is situated at first in the upper portion of the anterior triangle of the neck, where it has been previously described (see p. 1044). It leaves the neck and enters upon its facial course by mounting over the base and body of the inferior maxilla, in front of the anterior border of the masseter, where it is very superficial, being covered only by the platysma myoides and the integument. From this point it extends to the inner canthus of the eye, where it pierces the levator labii superioris alæque nasi, or becomes embedded in it, and terminates in its angular branch. Its course is upwards and forwards, and it describes many bends, being remarkable for its tortuosity, this being in adaptation to the great mobility of the surrounding parts. Though embedded in the fat, and covered by certain muscles, the facial part of the vessel is in no sense deeply placed.

Relations—*Superficial.*—The integument and platysma myoides, the risorius, the zygomatic muscles, and branches of the facial

nerve. Its relation to the levator labii superioris is variable. It may be under cover of, or over, that muscle. *Deep.*—The body of the inferior maxilla (where pulsation can readily be felt in the vessel), the buccinator, the levator anguli oris, and the infra-orbital nerve. *External.*—The facial vein, which is at a little distance from it, except at the body and base of the mandible, where the vein lies close to the outer side of the vessel.

Facial Branches.—(1) *Muscular branches*, of small size, arise from the outer side of the vessel, and are distributed to the structures in the masseteric, buccal, and infra-orbital regions, where they anastomose with the buccal, transverse facial, and infra-orbital arteries. (2) The *inferior labial artery* passes forwards over the body of the mandible, and beneath the depressor anguli oris, to supply the structures between the lower lip and the base of the mandible. It anastomoses with the inferior coronary, mental, and submental arteries. (3) The *inferior coronary artery* arises just below the angle of the mouth, and passes inwards beneath the depressor anguli oris. In the lower lip it lies near the margin, between the orbicularis oris and the mucous membrane, and it anastomoses with its fellow of the opposite side, and with the inferior labial. (4) The *superior coronary artery*, of larger size than the inferior, arises just above the angle of the mouth, under cover of the zygomaticus major. Its position in the upper lip is similar to that of the inferior coronary in the lower lip, and it anastomoses with its fellow of the opposite side. Near the middle line it furnishes the *artery of the septum nasi*, which ramifies on the columella nasi as far as the tip of the nose. The superior and inferior coronary arteries of each side sometimes arise together. The vessels of each side, superior and inferior, form in each lip a tortuous arterial arch, which is necessarily divided in operations upon one or other lip. (5) The *lateral nasal arteries* arise opposite the nose, upon the side of which they ramify. They anastomose with the nasal branch of the ophthalmic, the artery of the septum, the terminal branch of the anterior ethmoidal artery, and its fellow of the opposite side. (6) The *angular artery* is the terminal branch of the facial at the inner canthus of the eye. It lies either beneath, or embedded in, the levator labii superioris alæque nasi, and supplies the side of the root of the nose and the adjacent part of the orbicularis palpebrarum. It anastomoses with the nasal branch of the ophthalmic artery.

The **facial vein** commences above the inner canthus of the eye in the *angular vein*, which is formed by the union of the frontal and supra-orbital veins. The course of the vessel is downwards and outwards, external to the artery and at a little distance from it, except over the body and base of the inferior maxilla, where it lies close to its outer side and in contact with the anterior border of the masseter. The vein is much less tortuous than the artery, and in the lower part of its course descends almost vertically. The cervical part of the vein, which terminates in the internal jugular, has been already described. The muscular

relations of the vein correspond pretty much with those of the artery.

Its **tributaries** are as follows: (1) the frontal vein; (2) the supra-orbital vein, which communicates with the ophthalmic vein; (3 the angular vein, which receives internally the lateral na al veins, and externally a few superior palpebral veins, whilst posteriorly it communicates with the commencement of the superior ophthalmic vein, and internally with its fellow of the opposite side by means of the ***transverse nasal vein***, which lies over the bridge of

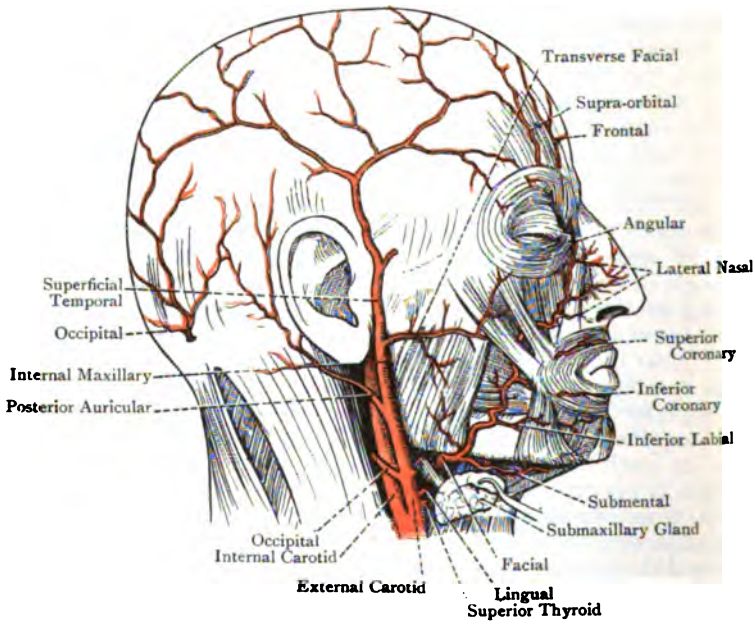


FIG. 463.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

the nose; (4) a few inferior palpebral veins, which are in communication with the infra-orbital vein; (5) the superior labial vein, which issues from a plexus in the upper lip (the blood from the similar plexus in the lower lip being chiefly conveyed by a few vessels to the roof of the digastric triangle of the neck, where they take part in the formation of the anterior jugular vein); (6) the deep facial vein, of large size, which, emerging from the pterygoid plexus, appears from behind the anterior border of the ramus of the inferior maxilla and of the masseter muscle, and passes forwards over the buccinator; and (7) parotid, masseteric, and buccal branches.

Transverse Facial Artery.—This vessel arises from the superficial

temporal in the parotid gland, and passes horizontally forwards. After emerging from beneath the anterior border of the gland it crosses the masseter, having the zygoma above it and Stensen's duct below it, the infra-orbital branches of the facial nerve being, in turn, below Stensen's duct. The order of structures from above downwards is, accordingly, artery, duct, and nerves. The artery is distributed to the parotid gland, the masseter muscle, and the structures on the side of the face, and it anastomoses with the infra-orbital, malar, facial, and buccal arteries.

The **transverse facial vein** opens into the superficial temporal vein.

The **nasal artery** is one of the terminal branches of the ophthalmic, and emerges from the orbit at the inner canthus above the internal tarsal ligament. It is distributed to the lachrymal sac and the side of the root of the nose, and anastomoses with the angular and lateral nasal arteries. It gives off a transverse nasal branch, which crosses the root of the nose and anastomoses with its fellow of the opposite side.

The **transverse nasal vein** connects the two angular veins over the root of the nose, and the other veins corresponding to the nasal artery open into the angular and superior ophthalmic veins.

The **supra-orbital** and **frontal arteries** have been already described (see pp. 992 and 993).

The **internal palpebral arteries,** *superior* and *inferior*, arise from the ophthalmic, and emerge from the orbit at the inner canthus, one passing above, and the other below, the internal tarsal ligament. Their course is outwards between the palpebral fibres of the orbicularis palpebrarum and the tarsal plates, and they anastomose, and form arches, with the palpebral branches of the lachrymal artery. They are distributed to the palpebral structures, the lachrymal sac, and the caruncula lacrimalis.

The **corresponding veins** from the upper eyelid open into the angular vein, and those from the lower eyelid into the facial vein.

The **terminal branch of the anterior ethmoidal artery** emerges, along with the terminal branch of the nasal nerve, between the lower border of the nasal bone and the upper lateral nasal cartilage. It is distributed to the skin of the tip, and the lower part of the side, of the nose.

The **external palpebral arteries,** *superior* and *inferior*, are branches of the lachrymal artery within the orbit. Their course is inwards between the palpebral fibres of the orbicularis palpebrarum and the tarsal plates, and they anastomose, and form arches, with the palpebral branches of the ophthalmic.

The **external palpebral veins** terminate in the orbital vein, which opens into the middle temporal vein, this in turn joining the superficial temporal vein.

The **temporal** and **malar arteries** are branches of the lachrymal, and they accompany the temporal and malar branches of the temporo-malar or orbital nerve.

The **orbital** and **anterior temporal arteries** have been already described (see pp. 996 and 997).

The **infra-orbital artery** arises from the third part of the internal maxillary in the spheno-maxillary fossa. Having passed horizontally forwards, with the infra-orbital nerve, through the infra-orbital canal it emerges with that nerve through the infra-orbital foramen, lying under cover of the levator labii superioris muscle. It then gives branches upwards to the lower eyelid, inwards to the side of the nose, and downwards towards the upper lip. It anastomoses with the inferior palpebral, facial, transverse facial, and buccal arteries.

The **infra-orbital vein,** having traversed the infra-orbital canal, opens into the pterygoid plexus.

The **buccal artery** is a branch of the second part of the internal maxillary. It accompanies the long buccal nerve to the superficial surface of the buccinator muscle, and is distributed to that muscle and to the mucous membrane of the cheek. It anastomoses with branches of the facial artery.

The **mental artery** is one of the terminal branches of the inferior dental from the first part of the internal maxillary, and it emerges from the dental canal of the inferior maxilla, along with the mental nerve, through the mental foramen, lying under cover of the depressor anguli oris muscle. It supplies the structures in this vicinity, and anastomoses with the inferior coronary, inferior labial, and submental arteries.

The **mental vein** joins the inferior dental vein, which opens into the pterygoid plexus.

Lymphatics.—The lymphatics of the face are arranged in two sets, superficial and deep. The *superficial lymphatics* for the most part take a course similar to that of the facial vein, and terminate in the submaxillary lymphatic glands. They receive the lymphatics of (1) the inner portion of the frontal region at the inner canthus; (2) the inner portions of the eyelids; (3) the side of the nose; (4) the portion of the face between the lower eyelid and upper lip; and (5) the upper and lower lips. The lymphatics from the temporal and outer part of the frontal regions, from the front of the auricle, from the outer portions of the eyelids, and from the outer part of the cheek terminate in the parotid lymphatic glands. The *deep lymphatics*, including those of the orbit, anterior part of the nasal cavity, roof of the mouth, and temporal and zygomatic fossæ, terminate in the internal maxillary glands.

Parotid Lymphatic Glands.—These glands are situated partly superficial to the parotid gland, where they lie beneath the parotid fascia, and partly within the gland along the course of the external carotid artery. They receive their afferent vessels from the outer surface of the auricle, the external auditory meatus, the temporal and frontal regions, and the lateral parts of the face. Their efferent lymphatics pass to the upper superficial cervical, and upper group of the deep cervical, glands.

Buccal Lymphatic Glands.—These glands are situated on the buccinator muscle. They receive their afferent lymphatics from the malar region and the lateral aspect of the face, and their efferent lymphatics pass to the parotid and submaxillary lymphatic glands.

Parotid Gland.—This salivary gland, which is of large size, is situated on the side of the face immediately in front of the auricle, and also below the auricle, where it occupies the space between the ramus of the lower jaw and the sterno-cleido-mastoid muscle. Its limits are as follows: *superiorly*, the zygoma; *inferiorly*, the stylo-maxillary ligament, in the direction of a line drawn from near the tip of the styloid process of the temporal bone to the angle of the inferior maxilla, this ligament separating it from the submaxillary gland; and *posteriorly*, the external auditory meatus, the mastoid process, and the anterior border of the sterno-cleido-mastoid muscle. The anterior border rests upon the posterior part of the masseter, and it is from this border, above its centre, that the parotid duct emerges. The duct is usually accompanied by a small portion of the gland, which lies above it, and may take the form of a distinct lobe. It is known as the *pars* or *glandula socia parotidis*. The superficial surface of the gland, which presents the usual lobulated appearance of compound racemose or acino-tubular glands, is covered by the parotid fascia, which is an upward extension of the deep cervical fascia. It is very dense, and consequently a parotid abscess is subjected to considerable tension. Lying beneath it, on the surface of the gland, there are the superficial set of parotid lymphatic glands. The deep connections of the gland are very intricate. It extends deeply between the mastoid process and sterno-cleido-mastoid behind, and the posterior border of the ramus and angle of the inferior maxilla in front. Superiorly, a deep extension of the gland, known as the *glenoid portion*, occupies the posterior part of the glenoid fossa, formed by the tympanic plate, and lying behind the fissure of Glaser. Lower down it extends both in front of, and behind, the styloid process and styloid muscles, and is here intimately related to the internal carotid artery, internal jugular vein, and glosso-pharyngeal, pneumogastric, spinal accessory, and hypoglossal nerves. The deep surface of the gland is invested by an upward extension of the deep cervical fascia, which, with the parotid fascia, forms a capsule for the gland. Anteriorly, the gland extends deeply behind the posterior border of the ramus of the lower jaw, as far at least as the posterior border of the internal pterygoid muscle, or it may be for a short distance between that muscle and the external pterygoid.

Several important structures traverse the gland. (1) The external carotid artery ascends deeply in it as high as the level of the neck of the inferior maxilla, where it divides into the superficial temporal and internal maxillary arteries, which are at first embedded in the gland. Whilst in the gland the superficial temporal artery gives off its transverse facial and auricular branches. (2) The super-

ficial temporal and internal maxillary veins unite in the gland, at the level of the neck of the inferior maxilla, to form the temporo-maxillary vein, which descends from that level within the gland, lying superficial to the external carotid artery, and close to the lower border of the gland it breaks up into an anterior and a posterior division. (3) The external jugular vein is formed in the lower part of the gland by the union of the posterior auricular vein with the posterior division of the temporo-maxillary vein. (4) The facial nerve traverses the gland from behind forwards, and, in doing so, breaks up into its temporo-facial and cervico-facial divisions, the branches of which emerge from the gland anteriorly and superiorly. The nerve is superficial to the external carotid artery

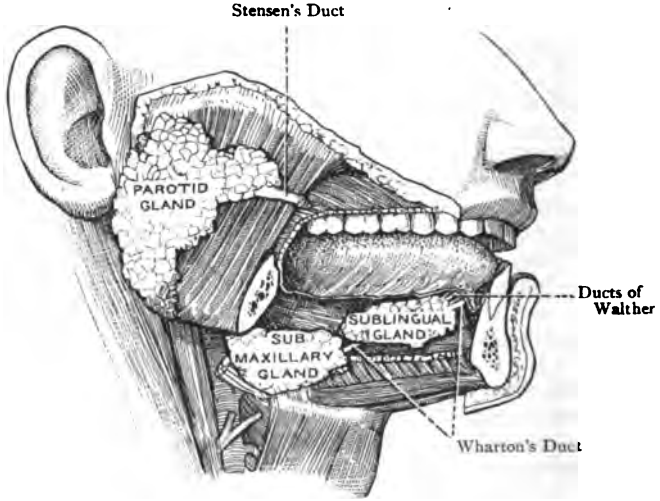


FIG. 464.—THE SALIVARY GLANDS OF THE RIGHT SIDE.

and temporo-maxillary vein. (5) Entering the lower part of the gland are branches of the great auricular nerve, which communicate within the gland with the facial nerve. (6) The auriculo-temporal nerve is related to the deep surface of the upper part of the gland, where it gives branches to it which communicate with the facial nerve.

Parotid Duct.—This excretory tube, which feels dense and tough, is usually called the duct of Stensen or Steno. It emerges from the anterior border of the gland, and passes forwards on the masseter muscle, lying fully ½ inch below the zygomatic arch. In this part of its course it is accompanied, for a short distance, by the pars or glandula socia parotidis, which, with the transverse facial artery, lies above it, whilst the infra-orbital branches of the facial nerve are placed below it. After leaving the surface of the masseter muscle the duct dips deeply through the fat covering the buccinator, and pierce-

that muscle. Thereafter it passes forwards for a very short distance beneath the buccal mucous membrane, which it finally pierces to terminate in a minute opening on a small papilla situated opposite the crown of the *second* upper molar tooth. The duct is about the size of a crow-quill, its diameter being about $\frac{1}{8}$ inch, except at its buccal orifice, where it becomes narrow. It is about 2 inches in length, and its course may be indicated by a line drawn from the incisura intertragica, or from the junction of the lobule and cartilage of the auricle, to a point midway between the nostril and the red margin of the upper lip. About the middle third of this line corresponds to the duct.

Blood-supply.—The arteries are derived from (1) the extern l carotid, (2) the superficial temporal, (3) the transverse facial, and (4) the posterior auricular.

Lymphatics.—These pass to the superficial and deep cervical glands, having previously traversed the parotid lymphatic glands, and, in the case of some, the submaxillary lymphatic glands.

Nerve-supply.—(1) The auriculo-temporal nerve, which conveys to the gland secretory fibres of the glosso-pharyngeal nerve through its tympanic branch (Jacobson's nerve), the small superficial petrosal nerve, and the otic ganglion; (2) the great auricular nerve; (3) the sympathetic plexus on the external carotid artery; and (4) the facial nerve.

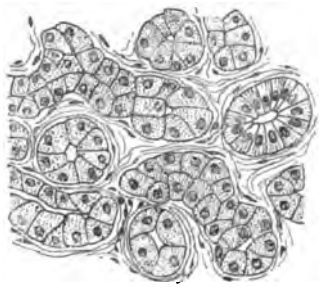


FIG. 465.—STRUCTURE OF THE PAROTID GLAND.

Structure.—The parotid gland is a compound racemose or acino-tubular gland, and is composed of large lobules, which are united by connective tissue. Each of these is made up of smaller lobules, likewise connected by connective tissue. Each small lobule is a gland on a minute scale, and is made up of a group of more or less sacculated tubules, called **alveoli** or **acini.** A duct passes from each small lobule, which unites with adjacent ducts, and these in turn unite, larger and still larger ducts being formed, the resultant being the principal duct, called Stensen's duct. Each alveolus is *serous* or *albuminous* as regards the nature of its secretion, and is composed of a basement membrane continuous with the wall of the duct, and surrounded by a plexus of capillaries. The alveolus is lined with polyhedral cells, which contain albuminous granules, and almost completely fill the tube, leaving only a small lumen. The first portion of the duct, called the *intercalary duct*, is lined with flattened epithelium. Beyond this the duct becomes constricted into a *neck*, which is lined with cubical cells, these being replaced in the intralobular duct by columnar cells. These cells are granular towards the lumen of the tube, but striated in the outer part. Each of the larger ducts is composed of a basement membrane, strengthened externally by a layer of connective tissue, superadded to which there is a stratum of plain muscular fibres.

Development.—The parotid gland appears in the early embryo as a small hypoblastic bud, situated in the angle between the maxillary and mandibular processes. This bud undergoes ramifications, which extend over the lower jaw, and so render the gland premandibular.

Ocular Appendages.

The appendages of the eye consist of the eyelids and the lachrymal apparatus.

Eyelids.—The **eyelids,** or **palpebræ,** are two movable curtains, placed in front of the eyeball, to which they form an important protection. The inner surface of each is covered by mucous membrane, which constitutes the **conjunctiva.** The upper eyelid is larger than the lower, and, when closed, covers the transparent part of the eye or cornea. It is also more movable than the lower, being provided with a special elevator muscle, namely, the levator palpebræ superioris. The elliptical interval between the lids is called the **fissura palpebrarum,** and the lateral extremities of this fissure are called the outer canthus and inner canthus. The **outer canthus** is formed by the junction between the two lids. At the **inner canthus** the lids are separated by a recess, called the **lacus lacrimalis,** in which there is a small body, called the **caruncula lacrimalis.** In this region the eyelids are separated from the eyeball by a vertical, semilunar fold of the conjunctiva, called the **plica semilunaris.** The margin of each eyelid presents, at the commencement of the lacus lacrimalis, a slight conical elevation, called the **papilla lacrimalis,** the apex of which presents a small orifice, termed the **punctum lacrimale,** its direction being towards the eyeball. Each punctum is the entrance to a passage, called the **canaliculus lacrimalis,** by which the tears are conveyed from the surface of the eyeball into the lachrymal sac, and thence, through the nasal duct, into the inferior meatus of the nasal fossa.

The free margins of the eyelids, external to the puncta lacrimalia, are provided with hairs, called the **cilia** or **eyelashes.** They are short, stout, and curved, and are arranged in two rows. Those of the upper lid are more numerous and larger than those of the lower. The upper eyelashes are curved upwards, and the lower downwards, and in this manner intermingling is avoided. Within the lines of attachment of the eyelashes there is a row of modified sweat-glands, known as the **glands of Moll,** the openings of which are associated with the follicles of the eyelashes, and with the condition known as *stye.*

Structure of the Eyelids.—Each eyelid is composed of the following structures, in order from without inwards :

1. Skin.
2. Connective tissue.
3. Palpebral fibres of the orbicularis palpebrarum.
4. Tarsal plate.
5. Meibomian glands.
6. Conjunctiva.

In addition to the foregoing structures the upper eyelid contains the tendinous insertion of the levator palpebræ superioris muscle.

The **skin** is very thin, and at the ciliary margins of the eyelids it becomes continuous with the conjunctiva, which is a mucous membrane. The **subcutaneous connective tissue** is very loose, and

devoid of fat. The **palpebral fibres of the orbicularis palpebrarum** form a very delicate, pale sheet. The **tarsal plate,** or **tarsus,** one for each eyelid, is a fibrous plate, and is composed of compact fibrous tissue. The **superior tarsal plate** is larger than the inferior, and is semilunar, its depth at the centre being about $\frac{1}{4}$ inch. Its upper and anterior part gives insertion to the levator palpebræ superioris. The **inferior tarsal plate** is narrow, and is almost of the same depth throughout. The *ciliary margins* of the tarsal plates are free, straight, and comparatively thick. The *orbital margins* are attached to the circumference of the orbit by membranous expansions, called the superior and inferior palpebral ligaments. The **superior palpebral ligament** is attached above to the upper part of the circumference of the orbit, where it blends with the periosteum, and below it blends with the tendon of insertion of the levator palpebræ superioris on the superior tarsal plate. The **inferior palpebral ligament** extends between the lower part of the circumference of the orbit and the lower margin of the inferior tarsal plate. The superior and inferior palpebral ligaments together constitute a partition, called the *septum orbitale,* which intervenes between the superficial and deep palpebral structures.

Externally and internally the tarsal plates have attachments by means of the tarsal ligaments, which are two in number, external and internal. The **external tarsal ligament** is formed by the junction of the superior and inferior palpebral ligaments, and is attached to the malar bone. The **internal tarsal ligament, tendo palpebrarum,** or **tendo oculi,** is independent of the palpebral ligaments. *Internally* it is attached to the external surface of the nasal process of the superior maxilla in front of the lachrymal groove. From this point it passes horizontally outwards for about $\frac{1}{6}$ inch, and then divides into two laminæ, which are attached to the superior and inferior tarsal plates. It passes in front of the lachrymal sac, and furnishes an offset, which passes behind the sac to be attached to the lachrymal crest of the lachrymal bone. The ligament gives origin to a few fibres of the orbicularis palpebrarum.

The **Meibomian glands** are situated on the internal surface of each tarsal plate, and lie between the plate and the conjunctiva at right angles to the ciliary margin. There are about thirty in the upper eyelid, and about twenty in the lower, and they are arranged in parallel rows, which occupy grooves on the ocular surface of each tarsal plate. Each gland opens by an independent orifice, and these orifices are arranged in a single row, lying a little behind the ciliary margin of the eyelid.

Structure.—The Meibomian glands are sebaceous glands, and their secretion lubricates the margins of the eyelids, and prevents them from adhering. Each consists of a tube, closed at one end, and having its sides beset with diverticula. The wall of the tube is composed of a basement membrane, which is lined with cubical epithelium throughout the greater part of the gland, but close to the orifice this is replaced by stratified epithelium.

In the vicinity of the closed ends of the Meibomian glands there are some convoluted tubules, which are known as the **posterior tarsal,** or **accessory lachrymal, glands,** the orifices of which are placed close to the fornix conjunctivæ.

Conjunctiva.—This is the mucous membrane which covers the ocular surfaces of the eyelids and the front of the eyeball. It consists of two parts—palpebral and ocular.

The **palpebral conjunctiva** lines the ocular or inner surfaces of the eyelids, and, at their ciliary margins, it is continuous with the skin on their outer surfaces. It is also continuous, through the puncta lacrimalia, with the lining membrane of the lachrymal canals, lachrymal sac, nasal duct, and inferior meatus of the nose. In the region of the inner canthus it gives rise to the plica semilunaris, and at the outer part of the upper eyelid it is continuous with the lining membrane of the lachrymal ducts. The palpebral conjunctiva is fairly thick and highly vascular, and it presents numerous papillæ.

The **ocular conjunctiva** consists of two portions—sclerotic and corneal. It is continuous with the palpebral conjunctiva, and the line of reflection from the eyelids is known as the **fornix conjunctivæ, superior** and **inferior** respectively. In this vicinity the orifices of the posterior tarsal, or accessory lachrymal, glands are met with. The *sclerotic conjunctiva* covers the part of the sclerotic which is adjacent to the cornea. It is loosely connected to the sclerotic, is thin, non-papillary, and transparent, and contains only a few blood-vessels, the whiteness of the sclerotic being unaffected by it. The *corneal conjunctiva* is very thin, and consists only of the conjunctival epithelium.

The palpebral conjunctiva is covered by columnar epithelium, which, at the ciliary margin, passes into the stratified epithelium of the skin ; the sclerotic conjunctiva is also covered by columnar epithelium ; but the corneal conjunctiva is represented by the stratified epithelium of the cornea.

The conjunctiva is supplied with blood by offsets from the palpebral branches of the ophthalmic artery and its lachrymal branch. The vessels are disposed in a tortuous manner, and are movable upon the eyeball when the conjunctiva is pressed upon and displaced. The nerves are numerous, and form plexuses. The lymphatics commence close to the corneal margin in a network, from which vessels proceed to a network in each eyelid behind the tarsal plate. The efferent vessels ultimately reach the parotid and submaxillary lymphatic glands.

The **caruncula lacrimalis** occupies the lacus lacrimalis in the region of the inner canthus. It is a small, reddish, spongy body, consisting of a detached portion of skin, containing modified sweat and sebaceous glands. The latter open into the follicles of very delicate hairs with which the surface of the caruncle is provided, and they furnish the white secretion which may accumulate at the inner canthus.

The **plica semilunaris** is a vertical, semilunar fold of the conjunctiva which is situated on the outer side of the caruncle, its concave margin being directed outwards. It corresponds to the *membrana nictitans*, or third eyelid, of some animals.

Development of the Eyelids.—The eyelids appear as two folds of the integument which unite along their margins about the third month of intra-uterine life. This union continues until shortly before birth, when they become separated.

Lachrymal Apparatus.—The constituent parts of the lachrymal apparatus are as follows :

1. The lachrymal gland.
2. The lachrymal canaliculi.
3. The lachrymal sac.
4. The nasal duct.

The **lachrymal gland** will be found described on p. 1071.

The **lachrymal canaliculi** are two in number, superior and inferior. They commence at the puncta lacrimalia on the summit of the

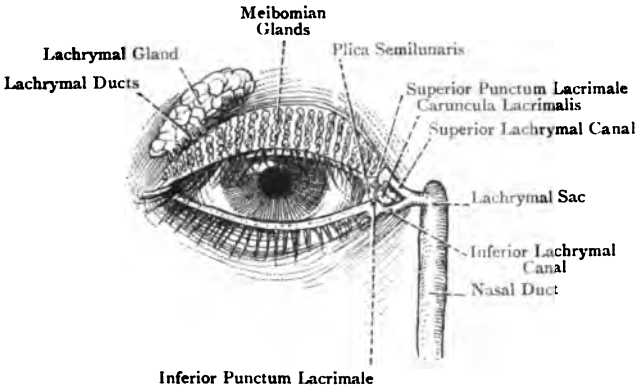


FIG. 1466.—THE LACHRYMAL APPARATUS OF THE RIGHT EYE.

(The Meibomian Glands of the Upper Eyelid are also shown).

papillæ lacrimales, which latter are situated on the ciliary margins of the eyelids, close to the lacus lacrimalis. The **superior canaliculus** at first ascends vertically for about $\frac{1}{12}$ inch, after which it makes a sudden bend, and passes inwards and downwards to the lachrymal sac. The **inferior canaliculus** at first descends vertically for about $\frac{1}{12}$ inch, after which it makes a sudden bend and passes almost horizontally inwards to the lachrymal sac. The two canaliculi open into the lachrymal sac, either close together or by a common orifice, and their mucous membrane is lined with stratified squamous epithelium. The two slips of the tensor tarsi muscle are closely related to the horizontal portions of the canaliculi.

The **lachrymal sac** is the dilated upper part of the passage by which the tears are conveyed from the lachrymal canaliculi to the

inferior meatus of the nose. It occupies the lachrymal groove of the lachrymal bone and nasal process of the superior maxilla. Superiorly it presents a round, closed extremity, and inferiorly it opens into the nasal duct. Externally it receives the lachrymal canaliculi, separately or conjointly, and anteriorly it is crossed by the tendo palpebrarum or internal tarsal ligament, which furnishes an offset round it. Posteriorly it is related to the tensor tarsi muscle.

The **nasal duct** extends from the lower end of the lachrymal sac to the anterior part of the inferior meatus of the nose, under cover of the front part of the inferior concha. Its length is about $\frac{3}{4}$ inch, and its diameter about $\frac{1}{8}$ inch. It is directed downwards, outwards, and backwards, and its opening into the anterior part of the inferior meatus of the nose is usually guarded by an imperfect mucous fold, known as the **valve of Hasner.** The nasal orifice of the duct is about $1\frac{1}{4}$ inches from the anterior nasal aperture.

Structure of the Lachrymal Sac and Nasal Duct.—The wall is composed of fibro-elastic tissue, which adheres closely to the periosteum of the bones, and is covered by mucous membrane. The epithelial lining is of the columnar variety, and at intervals the cells are furnished with cilia. The mucous membrane is continuous superiorly with the conjunctiva through the lachrymal canaliculi and puncta, and inferiorly it is continuous with the nasal mucous membrane. In the nasal duct it may present one or two folds.

Development.—The lachrymal canaliculi, lachrymal sac, and nasal duct, are generally regarded as being developed from the cleft between the lateral nasal process and maxillary process, which extends from the inner canthus of the eye to the nasal cavity.

Auricle.

The auricle, or pinna, is that part of the external ear which projects from the side of the head. It is somewhat pyriform, with the broad end upwards, and it presents two surfaces, outer and inner.

The **outer surface** is irregularly concave, and presents certain elevations and depressions. About its centre there is a large deep fossa, called the **concha,** which leads to the meatus auditorius externus. Towards the upper and anterior part of the concha there is an elevation, called the **crus helicis,** which is directed upwards and forwards to the anterior border of the auricle. The concha is thus divided into two parts, upper and lower. In front of the concha there is a small, somewhat conical, prominence, called the **tragus,** which projects slightly backwards over the orifice of the meatus auditorius externus, and is provided with hairs on its inner aspect. A short distance behind the tragus, and on a lower level than it, there is another prominence, called the **antitragus,** which is separated from the tragus by a deep notch, called the **incisura intertragica.** The skin over the antitragus is also provided with hairs. Below the antitragus and incisura intertragica is the most dependent part of the auricle, called the **lobule,** which is comparatively soft in consistence. The prominent rim of the auricle is called the **helix.** It is incurved, and commences at the upper and anterior

part of the concha in the crus helicis, already referred to. Thereafter it surrounds the upper part of the anterior margin, and the superior and posterior margins, of the auricle, and subsides below in the back part of the lobule. In some cases the helix presents a projection, called the **tubercle of Darwin,** which is situated on the incurved margin, slightly above the level where the antihelix, to be presently described, bifurcates into its crura. This projection is well developed in the ears of quadrupeds, and forms the *point* or *tip*. A short distance within the helix there is another curved elevation, called the **antihelix.** This commences inferiorly at the back part of the antitragus and ascends behind the concha, above

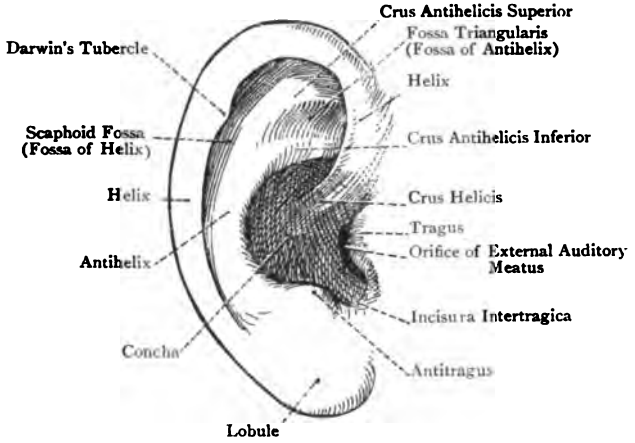


FIG. 467.—THE RIGHT AURICLE (EXTERNAL VIEW).

which it divides into two diverging crura, upper and lower. Between the helix and the antihelix is an elongated, narrow fossa, called the **fossa of the helix,** or the **scaphoid fossa,** and between the diverging crura of the antihelix there is a depression, called the **fossa of the antihelix** or the **triangular fossa.**

The **inner** or **cranial surface** of the auricle presents convexities corresponding to the fossæ on the outer surface, the convexity opposite the concha being especially prominent.

Structure of the Auricle.—The auricle, with the exception of the lobule, is composed of a plate of yellow elastic fibro-cartilage covered by skin. This plate imparts firmness and elasticity to it, and is provided with ligaments and intrinsic muscles. The skin is thin, and adheres closely to the fibro-cartilaginous plate. It is provided with hairs, which are most plentiful in the regions of the tragus and antitragus. The cartilage of the auricle is rolled upon itself so as to form the outer or cartilaginous part of the meatus auditorius externus. This portion of it is attached internally to the external auditory process of the temporal bone by fibrous tissue. The rolled or tubular portion presents a deficiency at the anterior and upper part, between the tragus and the commencement of the helix, which is occupied by a fibrous

membrane. It also presents a variable number of transverse clefts, called the **fissures of Santorini,** which are filled with fibrous tissue. The lower extremity of the cartilage of the helix is separated from the cartilage of the antihelix by a deep cleft. The part of the cartilage of the helix behind this cleft is known as the **processus caudatus helicis.** At the upper and anterior part of the auricle, where the helix begins to curve backwards, the cartilage presents a small sharp projection, called the **spine of the helix.**

Ligaments of the Auricle.—These are two in number, anterior and posterior. The **anterior ligament** extends from the spine of the helix to the zygoma of the temporal bone close to its root.

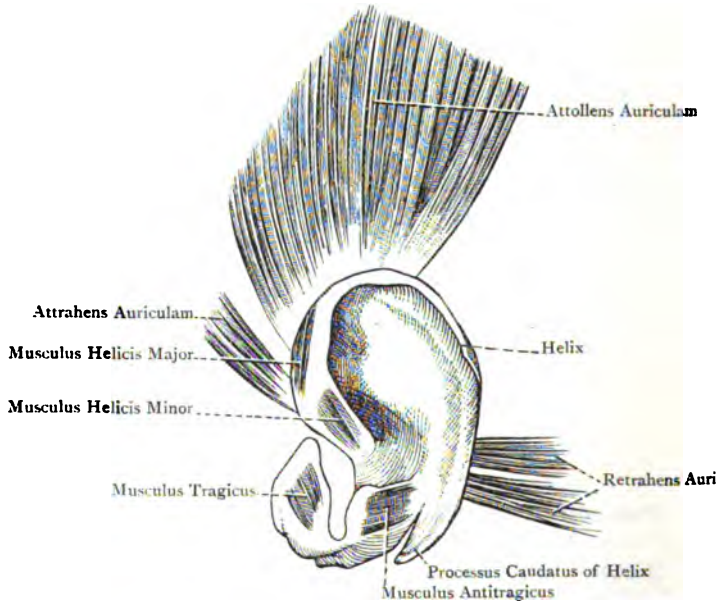


FIG. 468.—THE OUTER SURFACE OF THE LEFT AURICLE AND ITS MUSCLES (ARNOLD).

The **posterior ligament** extends from the cranial aspect of the concha, under cover of the retrahens auriculam muscle, to the mastoid process.

Intrinsic Muscles.—These muscles, which are very thin and pale, are confined to the auricle and are six in number, four being situated on the outer surface, and two on the inner surface.

Muscles on Outer Surface.—These are as follows : (1) the musculus helicis major ; (2) the musculus helicis minor ; (3) the musculus tragicus ; and (4) the musculus antitragicus.

The **musculus helicis major** extends from the spine of the helix along the anterior part of the helix as high as the level at which it curves backwards.

The **musculus helicis minor** lies upon the crus helicis.

The **musculus tragicus** lies upon the outer surface of the tragus, its fibres being almost vertical.

The **musculus antitragicus** extends from the outer surface of the antitragus backwards and slightly upwards, to be attached to the processus caudatus of the helix.

Muscles on Inner Surface.—These are as follows : (1) the musculus transversus, and (2) the musculus obliquus.

The **musculus transversus** extends over the depression which corresponds to the antihelix on the outer surface, its attachments

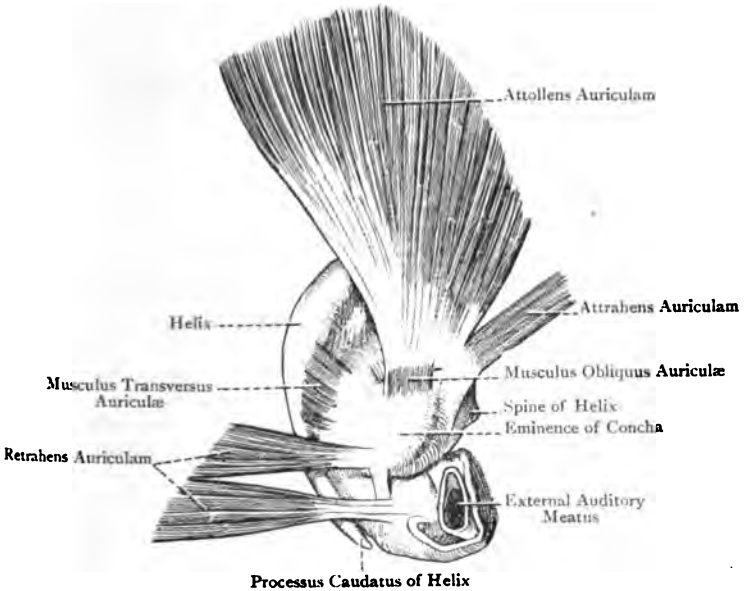


FIG. 469.—THE INNER SURFACE OF THE LEFT AURICLE AND ITS MUSCLES (ARNOLD).

being to the convexity of the concha on the one hand, and the convexity of the fossa of the helix on the other.

The **musculus obliquus** extends over the depression corresponding to the lower crus of the antihelix on the outer surface.

Action of the Intrinsic Muscles.—The musculus tragicus and musculus antitragicus diminish the orifice of the meatus auditorius externus, and the muscles of the helix, major and minor, have an opposite effect.

Nerve-supply.—The facial nerve.

Blood-supply of the Auricle.—The arteries are derived from (1) the posterior auricular branch of the external carotid, (2) the anterior auricular branches of the superficial temporal, and (3) the deep auricular branch of the first part of the internal maxillary,

the last named giving offsets to the cartilaginous part of the meatus auditorius externus.

The **veins** terminate in the posterior auricular, superficial temporal, and internal maxillary veins, and one or two of them may open into the mastoid emissary vein.

The **lymphatics** pass to the mastoid glands and to the parotid lymphatic glands.

Nerve-supply.—The **inner surface** receives three cutaneous nerves, as follows: the great auricular supplies about the lower three-fourths, the small occipital about the upper fourth, and the auricular branch (Arnold's nerve) of the pneumogastric supplies the integument over the convexity of the concha. The **outer surface** is supplied by two cutaneous nerves, as follows: the auriculo-temporal nerve supplies the upper two-thirds, and the great auricular supplies the lower third. The motor nerve of the intrinsic muscles is, as stated, the facial nerve.

The Nose.

The nose, as it appears upon the face, presents a **root,** situated below the glabella of the frontal bone; a **tip,** or **point,** situated inferiorly; and a **dorsum,** which occupies an intermediate position. The upper part of the dorsum is known as the **bridge of the nose.** At the lower part of the nose there are the openings of the **nostrils,** or **anterior nares.** The outer margin of each nostril is slightly prominent and curved, and is called the **ala.** The nostrils are separated from each other by a septum, called the **columella nasi,** which, as well as the ala, is composed of fibrous tissue and skin. Within the circumference of each nostril there are several stout hairs or *vibrissæ.*

FIG. 470.—THE CARTILAGES OF THE NOSE (ANTERIOR VIEW) (ARNOLD).

The superficial or facial aspect of the nose derives its **arteries** from (1) the lateral nasal and angular branches of the facial, and (2) the nasal branch of the ophthalmic.

The **nerves** are derived from the nasal and infra-orbital nerves, the branches from the nasal being the infratrochlear and the terminal cutaneous offsets.

The lymphatics pass to the submaxillary lymphatic glands.

The framework of the nose is both osseous and cartilaginous.

Cartilages of the Nose.—The nasal cartilages are five in number, as follows :

Upper lateral, right and left.
Lower lateral, right and left.
Septal.

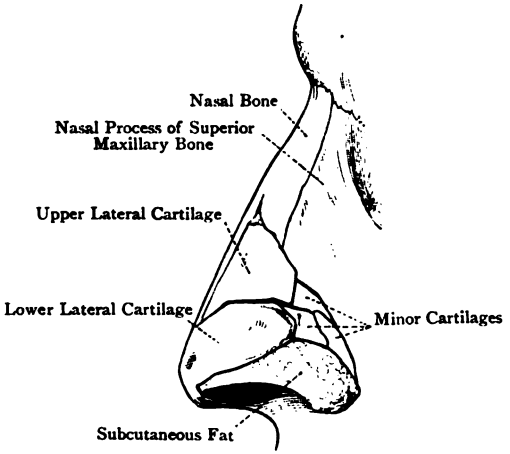


FIG. 471.—THE CARTILAGES OF THE NOSE (LATERAL VIEW) (ARNOLD).

The **upper lateral cartilages** are situated immediately below the nasal bones. They are triangular, and their *anterior borders* are continuous with each other, and with the anterior margin of the

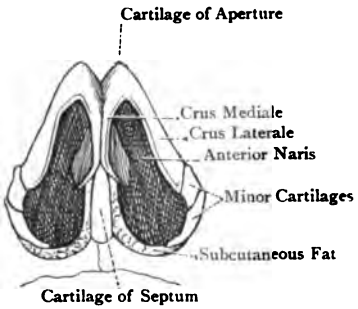


FIG. 472.—THE CARTILAGES OF THE NOSE (INFERIOR VIEW) (ARNOLD).

septal cartilage, in each case superiorly. Inferiorly, the anterior borders are separated by a slight interval, in which the anterior margin of the septal cartilage is visible. The *posterior border* of each cartilage is attached to the lower sloping border of the nasal bone, and also to the upper part of the nasal notch on the mesial

border of the superior maxilla. The *lower border* is connected by fibrous tissue to the upper margin of the lower lateral cartilage.

The **lower lateral cartilages** are also known as the **cartilages of the apertures.** They are situated below the upper pair, and each is bent so as to lie in front, and on each side, of the nostril, which it keeps open. Its outer portion is called the crus laterale, and its inner portion the crus mediale.

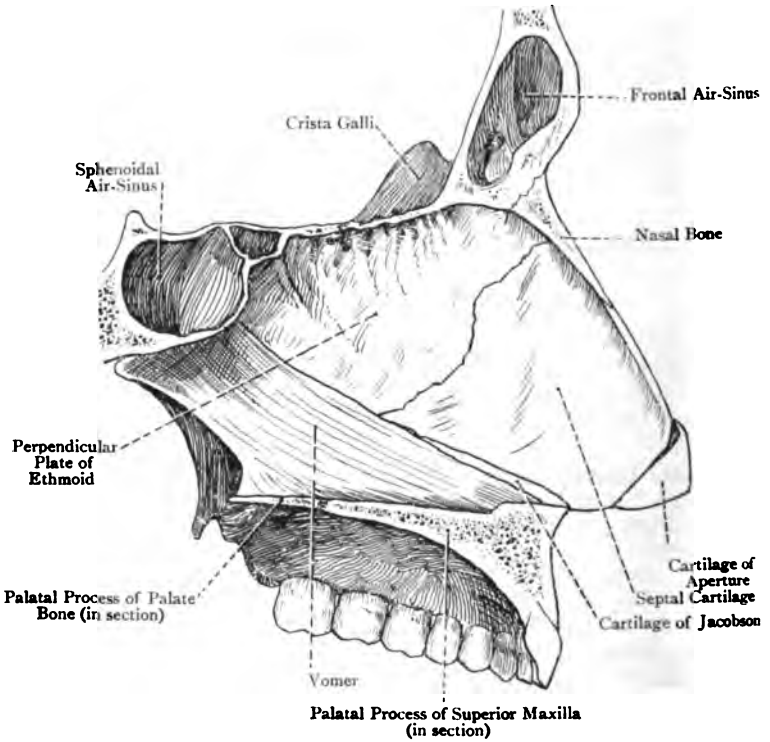


FIG. 473.—THE OSSEOUS AND CARTILAGINOUS NASAL SEPTUM (RIGHT LATERAL VIEW).

The *crus laterale* is attached by fibrous tissue to the upper lateral cartilage, and to the lower part of the nasal notch on the mesial border of the superior maxilla. The *crus mediale* is folded backwards, and is contiguous to its fellow of the opposite side. It lies along the upper part of the columella nasi, and along the antero-inferior border of the cartilage of the septum. Anteriorly it is separated from its fellow by a notch.

In the fibrous tissue which connects the crus laterale to the superior maxilla two or more isolated portions of cartilage are met with, called the **sesamoid** or **minor cartilages.**

The lateral nasal cartilages are the remains of the fronto-nasal plate of the primitive cartilaginous skull.

The **cartilage of the septum** is mesially placed, and is usually inclined slightly to one side, most frequently the left. It forms a large part of the nasal septum anteriorly, and has the form of an irregularly four-sided, laterally-compressed plate. Its *anterior border* is attached to the back of the nasal bones, along the course of the internasal suture; below this it is connected to the anterior borders of the lateral nasal cartilages; and below these it lies between the crura medialia of the lower nasal cartilages. Its *posterior border* is accurately applied to the irregular anterior margin of the perpendicular plate of the ethmoid bone. Its *inferior border* is received into the front part of the groove on the anterior border of the vomer. The *antero-inferior border* passes upwards and forwards from the front part of the inferior border to the anterior border. In early life the septal cartilage is prolonged backwards to the body of the sphenoid bone in the form of a narrow strip, which intervenes between the lower border of the perpendicular plate of the ethmoid and the vomerine groove. This portion is known as the *sphenoidal* or *posterior process*. Along the inferior border of the septal cartilage, between it and the anterior border of the vomer, there are two narrow, elongated strips of cartilage, right and left, which are called the **cartilages of Jacobson,** or the **vomerine cartilages of Huschke.**

The septal cartilage is the persistent remains of the anterior extremity of the ethmo-vomerine plate of the primitive cartilaginous skull.

The Temporal and Ptergyo-maxillary Regions.

Muscles of Mastication.—These are four in number, namely, the masseter, temporal, external pterygoid, and internal pterygoid.

Masseter—*Origin*—(1) **Superficial Portion.**—The anterior two-thirds of the lower border of the zygomatic arch. (2) **Deep Portion.**—The posterior third of the lower border, and the whole of the deep or internal surface of the zygomatic arch.

Insertion.—The superficial portion is inserted into the lower half, and the deep portion into the upper half, of the outer surface of the ramus of the inferior maxilla. The superficial fibres extend as far as the angle, and the deep fibres encroach on the coronoid process.

Nerve-supply.—The masseteric branch of the anterior portion of the inferior maxillary division of the fifth cranial nerve. This branch emerges from the pterygoid region by passing over the sigmoid notch of the inferior maxilla, below the zygoma, and it therefore enters the muscle on its deep surface, accompanied by the masseteric artery.

The superficial portion of the muscle is directed downwards and slightly backwards, and the deep portion downwards and very slightly forwards.

Action.—To elevate the inferior maxilla. The superficial portion also draws it slightly forwards.

Relations—*Superficial.*—The parotid gland and Stensen's duct, branches of the facial nerve, the transverse facial artery, the risorius, and the platysma myoides. *Deep.*—The ramus of the inferior maxilla, and the masseteric nerve and artery. The *anterior border* overlaps the buccinator, from which it is separated by the buccal pad of fat.

Temporal Muscle—*Origin.*—(1) The temporal fossa, extending as high as the inferior temporal ridge of the frontal and parietal bones, and as low as the infratemporal crest on the external surface of the great wing of the sphenoid, but excluding the portion of the fossa formed by the malar bone; and (2) the deep surface of the temporal fascia over its upper part.

Insertion.—(1) The internal surface, and superior and posterior borders, of the coronoid process of the inferior maxilla; and (2) the elongated triangular surface on the internal surface of the ramus of the inferior maxilla, close within the anterior border, and extending as low as a point on the inner side of the last molar alveolus.

Nerve-supply.—The deep temporal nerves, usually three in number, which are branches of the anterior portion of the inferior maxillary division of the fifth cranial nerve, and which enter the deep surface of the muscle.

The muscle is fan-shaped. The anterior fibres descend almost vertically; the middle fibres pass obliquely downwards and forwards; and the posterior fibres pass forwards almost horizontally.

Action.—To raise the inferior maxilla, that is, to draw it upwards into contact with the superior maxilla, as in closing the mouth. The posterior fibres also retract the inferior maxilla, and act in opposition to the external pterygoid, which protracts it.

Relations—*Superficial.*—The temporal fascia, supporting the attrahens and attollens auriculam muscles; the superficial temporal artery, auriculo-temporal nerve, and temporal branches of the facial nerve; the zygoma; and fat, which is continuous with the buccal pad. *Deep.*—The temporal fossa, the deep temporal arteries and nerves, and the external pterygoid muscle.

The long buccal nerve passes downwards and forwards under cover of the muscle close to the anterior border of the ramus of the inferior maxilla, and the masseteric nerve and artery pass forwards close to the posterior border in the region of the sigmoid notch of the inferior maxilla.

For the temporal fascia, see p. 999.

External Pterygoid—*Origin*—(1) **Upper Head.**—The zygomatic division of the outer surface of the great wing of the sphenoid, below the infratemporal crest. (2) **Lower Head.**—The outer surface of the external pterygoid plate of the sphenoid. The upper head is small, and the lower head is of large size.

Insertion.—(1) The depression on the front of the neck of the

inferior maxilla ; and (2) the front of the interarticular fibro-cartilage of the temporo-mandibular joint.

Nerve-supply.—The external pterygoid nerve, which is a branch of the long buccal nerve, that, in turn, being a branch of the anterior portion of the inferior maxillary division of the fifth cranial nerve.

The direction of the muscle is backwards and slightly outwards.

Action.—(1) To draw forwards the neck and condyle of the inferior maxilla, and also the interarticular fibro-cartilage. When the muscles of opposite sides act in concert the inferior maxilla is protruded, and the lower incisor and canine teeth project beyond the level of those of the superior maxilla. The muscles of opposite sides, however, usually act in reciprocal succession, as in the

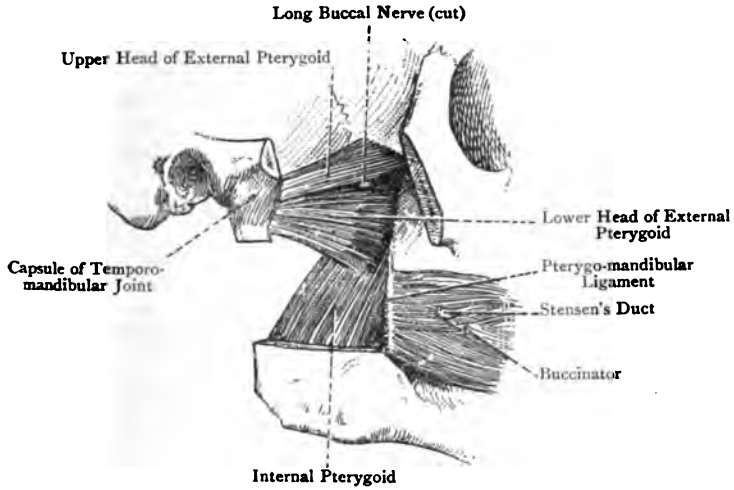


FIG. 474.—THE PTERYGOID AND BUCCINATOR MUSCLES.

oblique or grinding movement, the lower molars of one side being carried forwards and inwards upon the corresponding upper molars, and *vice versâ*. At the same time the elevators of the inferior maxilla are in action. (2) To take part in opening the mouth by drawing the condyle of the inferior maxilla and interarticular fibro-cartilage forwards on to the *eminentia articularis* of the temporal bone. The external pterygoid is antagonistic to the posterior portion of the temporal muscle.

Relations—*Superficial.*—Part of the ramus of the inferior maxilla, the lower part of the temporal muscle, part of the pterygoid plexus of veins, the long buccal nerve, and, it may be, the second part of the internal maxillary artery. *Deep.*—The upper portion of the internal pterygoid muscle, the spheno-mandibular ligament, in some cases the second part of the internal maxillary artery, the middle meningeal artery, a part of the pterygoid plexus of veins,

the inferior maxillary nerve, the otic ganglion, and the chorda tympani nerve. *Superior.*—The masseteric and middle and posterior deep temporal nerves. *Inferior.*—The inferior dental and lingual nerves, and the spheno-mandibular ligament. The long buccal nerve, with the anterior deep temporal nerve, makes its appearance between the upper and lower heads, and the internal maxillary artery may sink between them.

Internal Pterygoid—*Origin.*—(1) The inner surface of the external pterygoid plate of the sphenoid, and the portion of the tuberosity of the palate bone which forms the lower part of the pterygoid fossa; and (2) the outer surface of the tuberosity of the palate bone, and the adjacent portion of the tuberosity of the superior maxilla.

Insertion.—(1) The inner aspect of the angle of the inferior maxilla; and (2) the back part of the inner surface of the ramus, between the angle and the dental foramen.

Nerve-supply.—The internal pterygoid branch of the anterior portion of the inferior maxillary division of the fifth cranial nerve.

The direction of the muscle is downwards, backwards, and outwards.

Action.—(1) To elevate the inferior maxilla; and (2) to draw it forwards.

Relations—*Superficial.*—The external pterygoid muscle to a slight extent superiorly, the spheno-mandibular ligament, the internal maxillary and inferior dental vessels, and the inferior dental and lingual nerves. *Deep.*—The tensor palati muscle, and the superior constrictor muscle of the pharynx.

For a description of the spheno-mandibular ligament, see p. 1136.

Internal Maxillary Artery.—This vessel is the larger of the two terminal branches of the external carotid. It arises from that artery opposite the neck of the inferior maxilla, and within the parotid gland. Its course is at first forwards and inwards behind the neck of the mandible, and superficial to the spheno-mandibular ligament. It then inclines upwards and forwards through the zygomatic fossa, usually passing superficial to the external pterygoid muscle, though in many cases it passes beneath it. Having reached the interval between the two heads of the external pterygoid, it sinks deeply between them, and, passing through the pterygo-maxillary fissure, it enters the spheno-maxillary fossa, where it gives off its terminal branches. In those cases where the artery passes beneath the external pterygoid muscle, it forms a projecting curve between the two heads of the muscle. The course of the vessel is very tortuous in adaptation to the mobility of the surrounding structures.

Owing to its complexity it is convenient to divide the artery into three parts, namely, first, second, and third. The **first, or mandibular, part** is situated between the neck of the inferior maxilla and the spheno-mandibular ligament, and its course is horizontally forwards and inwards. It is accompanied by the internal maxillary vein, and

lies along the back part of the lower border of the external pterygoid muscle, crossing in front of the inferior dental nerve. The **second, or pterygoid, part** usually lies upon the lower head of the external pterygoid, and under cover of the insertion of the temporal muscle. Its course through the zygomatic fossa is upwards and forwards, and it sinks between the two heads of the external pterygoid on its way to the pterygo-maxillary fissure. In many cases, however, the second part of the vessel passes beneath the lower head of the external pterygoid, crossing in front of the internal pterygoid muscle and lingual nerve. Under these circumstances it forms a projecting curve between the two heads of the external pterygoid beneath the long buccal nerve. The **third, or spheno-maxillary, part** is situated in the spheno-maxillary fossa, which it enters by passing through the pterygo-maxillary fissure. In this fossa the vessel and its branches are intimately related to the superior maxillary nerve and Meckel's ganglion, with its branches.

Branches.—These are as follows :

First Part.	Second Part.	Third Part.
Deep auricular.	Masseteric.	Posterior dental.
Tympanic.	Internal pterygoid.	Infra-orbital.
Middle meningeal, giving off small meningeal.	External pterygoid.	Descending palatine.
	Posterior deep temporal.	Vidian.
Inferior dental.	Anterior deep temporal.	Pterygo-palatine.
	Buccal.	Spheno-palatine.

Branches of the First Part.—The **deep auricular artery,** of small size, ascends within the parotid gland, just behind the temporo-mandibular joint, and pierces the anterior cartilaginous wall of the meatus auditorius externus. It supplies the cutaneous lining of that passage, and the outer surface of the membrana tympani.

The **tympanic artery** may be associated with the preceding at its origin. It ascends beneath the external pterygoid, and enters the tympanic cavity by passing through the fissure of Glaser. It is distributed to the structures within the tympanum, and to the inner surface of the membrana tympani. Around the circumference of that membrane it forms an arterial ring with an offset of the stylo-mastoid artery, which is a branch of the posterior auricular.

The **middle meningeal artery,** of large size, ascends beneath the external pterygoid muscle, and, passing between the two roots of origin of the auriculo-temporal nerve, it enters the cranial cavity through the foramen spinosum in the sphenoid bone. It then passes upwards and forwards to the inner aspect of the antero-inferior angle of the parietal bone, where it divides into two branches, anterior and posterior, which ramify in the branching grooves on the inner surface of the parietal bone. The artery is accompanied by a plexus of sympathetic nerves, and by two veins. For the distribution of the vessel within the cranium, see p. 1356. Before disappearing through the foramen spinosum the middle meningeal

artery usually gives off the *small meningeal artery*, which enters the cranial cavity through the foramen ovale (see p. 1356).

The **inferior dental artery** arises nearly opposite the middle meningeal artery, and descends upon the spheno-mandibular ligament in company with the inferior dental nerve, lying on its posterior and outer side. Having reached the inferior dental foramen, it gives off the small *mylo-hyoid artery*, and then it passes through the inferior dental foramen and enters the inferior dental canal which it traverses as far as the level of the mental foramen, where

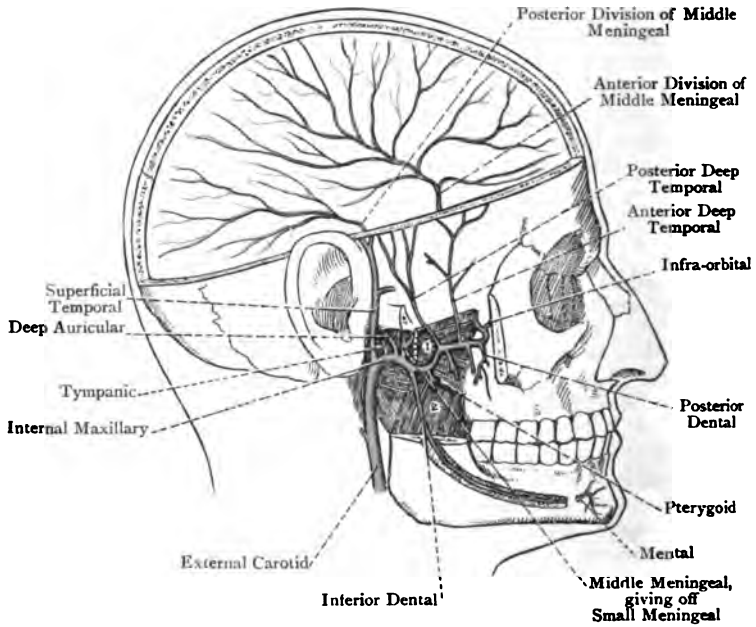


FIG. 475.—THE INTERNAL MAXILLARY ARTERY AND ITS BRANCHES.

(The Ramus of the Mandible and one half of the Calvaria have been removed).

it ends by dividing into its mental and incisor branches. Within the inferior dental canal the artery is accompanied by the inferior dental nerve and inferior dental vein.

Branches.—The *mylo-hyoid artery*, of small size, arises at the level of the inferior dental foramen. In company with the mylo-hyoid nerve it pierces the spheno-mandibular ligament, and descends in the mylo-hyoid groove to be distributed to the under surface of the mylo-hyoid muscle. The *molar*, *bicuspid*, and *canine branches* arise within the inferior dental canal, and supply the pulps of these teeth, which they reach by passing through the foramina on the extremities of their fangs. The *mental artery* emerges from the

inferior dental canal through the mental foramen, and has been already described (p. 1106). The *incisor artery* supplies the pulps of the incisor teeth of one side.

Branches of the Second Part.—The branches of this part are muscular in their distribution. The **masseteric artery** passes outwards, with the corresponding nerve, over the sigmoid notch of the inferior maxilla, and enters the deep surface of the masseter. The **internal** and **external pterygoid branches** are distributed to the corresponding muscles. The **posterior** and **anterior deep temporal arteries** pass upwards to the posterior and anterior parts of the temporal fossa beneath the temporal muscle. They supply the muscle and the bones forming the fossa, and anastomose with the middle temporal artery, which is a branch of the superficial temporal. The anterior deep temporal artery also anastomoses with the lachrymal artery by twigs which pass through minute foramina in the outer wall of the orbit. The **buccal artery** passes downwards and forwards in company with the long buccal nerve, and is distributed to the buccinator muscle and the buccal mucous membrane which lines it internally.

Branches of the Third Part.—The **posterior dental artery** arises from the internal maxillary as it is about to pass through the pterygo-maxillary fissure into the spheno-maxillary fossa, and is sometimes associated with the infra-orbital artery at its origin. It descends upon the zygomatic surface of the superior maxilla, posterior to the malar process, and its principal branches traverse the posterior dental canals to supply the pulps of the upper molar teeth of one side. It also furnishes twigs to the mucous lining of the antrum of Highmore, and to the gum.

The **infra-orbital artery** arises in the spheno-maxillary fossa, sometimes in common with the posterior dental. It passes through the spheno-maxillary fissure in company with the superior maxillary nerve, and traverses the infra-orbital groove and canal on the floor of the orbit, the accompanying nerve being now called the infra-orbital nerve. From this canal it emerges through the infra-orbital foramen on to the face, where it has been already described (see p. 1106). The artery is accompanied by the infra-orbital vein. As the artery traverses the infra-orbital canal it furnishes (1) *orbital branches* to the structures on the floor of the orbit; and (2) the *middle* and *anterior dental arteries*, which descend in the middle and anterior dental canals in the superior maxilla, in company with the corresponding nerves, to supply the pulps of the upper bicuspid, incisor, and canine teeth of one side, and the mucous lining of the antrum of Highmore.

The **descending palatine artery** passes downwards in the posterior palatine canal, in company with the great or anterior descending palatine nerve, to the hard palate, where it passes forwards and inwards to the anterior palatine fossa. In this situation it furnishes a branch which ascends through the incisor canal, or canal of Stensen, to anastomose with the naso-palatine artery. As the artery

traverses the posterior palatine canal it gives off a posterior and an external branch, which accompany corresponding nerves in the posterior and external accessory palatine canals, and supply the soft palate and tonsil.

The **Vidian artery** passes backwards through the Vidian canal in company with the Vidian nerve, and its branches are : (1) *pharyngeal*, to the upper part of the pharynx ; (2) *Eustachian*, to the Eustachian tube ; and (3) *tympanic*, to the tympanum.

The **pterygo-palatine artery**, of small size, passes backwards through the pterygo-palatine canal, in company with the pharyngeal nerve, and is distributed to the upper part of the pharynx, the Eustachian tube, and the mucous lining of the corresponding sphenoidal air-sinus.

The **spheno-palatine artery** enters the superior meatus of the nasal fossa through the spheno-palatine foramen. Its branches are distributed extensively on the outer wall of the nasal fossa, and supply the mucous membrane of the antrum, ethmoidal cells, and frontal air-sinus. One branch, called the *naso-palatine artery*, or *artery of the septum*, descends upon the septum to the incisor foramen, where it anastomoses with the ascending branch of the descending palatine artery.

Pterygoid Plexus of Veins.—This is a large plexus which surrounds the external pterygoid muscle. Its tributaries correspond, for the most part, to the branches of the internal maxillary artery, and are chiefly as follows : the deep auricular, tympanic, two middle meningeal, inferior dental, masseteric, pterygoid, deep temporal, buccal, superior dental, infra-orbital, palatine, and spheno-palatine. The blood is conveyed away from the plexus by two veins, namely, the internal maxillary and the deep facial.

The **internal maxillary vein** is a short vessel which issues from the posterior part of the plexus, and accompanies the first part of the internal maxillary artery. Opposite the neck of the inferior maxilla it joins the superficial temporal vein within the parotid gland to form the temporo-maxillary vein.

The **deep facial vein** issues from the anterior part of the pterygoid plexus, and, passing downwards and forwards, it emerges from behind the mandibular ramus and masseter muscle, and joins the facial vein on the buccinator muscle. The pterygoid plexus establishes the following important connections superiorly : it communicates with the intracranial cavernous sinus by means of emissary veins, which pass through the foramen ovale, foramen Vesalii, and foramen lacerum medium ; and it communicates with the inferior ophthalmic vein at the spheno-maxillary fissure.

Internal Maxillary Lymphatic Glands.—These glands lie along the internal maxillary artery, upon the back part of the buccinator muscle, and upon the upper part of the lateral wall of the pharynx. They receive their afferent lymphatics from the following sources : the temporal and zygomatic regions, the orbit, the posterior two-thirds of the nasal fossa, the soft palate and roof of the mouth,

the upper part of the pharynx, and the meninges of the brain. Their efferent vessels pass to the upper group of deep cervical glands.

Inferior Maxillary Nerve.—This is the **third division** of the fifth nerve. It is a mixed nerve, and consists of two roots—sensory and motor. The *sensory root*, which is of large size, arises from the Gasserian ganglion, and the *motor root* represents the entire motor root of the fifth nerve. Both roots leave the cranial cavity through the foramen ovale, and immediately after their exit they unite to form a mixed nerve, that is to say, a nerve composed of both sensory and motor fibres. This nerve is very short, and lies deeply in the zygomatic fossa, under cover of the external pterygoid muscle, where it gives off two branches, namely, a recurrent branch, and the internal pterygoid nerve. Thereafter it immediately breaks up into two parts, known as the anterior and posterior divisions. The *recurrent branch* enters the cranial cavity through the foramen spinosum, along with the middle meningeal artery, and divides into two branches—anterior and posterior. The anterior branch is distributed to the adjacent dura mater, and the posterior branch passes through the fissure between the petrous and squamous parts of the temporal bone, to be distributed to the mucous lining of the mastoid cells. The *internal pterygoid nerve* arises from the deep surface of the undivided inferior maxillary nerve, and passes downwards to enter the deep surface of the internal pterygoid muscle. Close to its origin it is intimately related to the otic ganglion.

Anterior Division of the Inferior Maxillary Nerve.—This division is smaller than the posterior, and is principally motor in function, the only sensory branch furnished by it being the long buccal nerve. Its branches are as follows: (1) masseteric, furnishing the posterior deep temporal; (2) middle deep temporal; and (3) long buccal, giving off the external pterygoid and anterior deep temporal, after which it is purely sensory.

The *masseteric nerve* passes upwards beneath the upper head of the external pterygoid muscle, where it furnishes the posterior deep temporal nerve. It then passes outwards over the upper border of the external pterygoid, and over the sigmoid notch of the lower jaw, behind the temporal muscle, to enter the upper part of the masseter on its deep surface.

The *deep temporal nerves* are three in number—anterior, middle, and posterior. The *anterior deep temporal nerve* usually arises from the long buccal after it has emerged between the two heads of the external pterygoid. It passes upwards, superficial to the upper head of that muscle, and enters the anterior part of the temporal muscle on its deep surface. The *middle deep temporal nerve* is a direct branch of the anterior division of the inferior maxillary, and it ascends beneath the external pterygoid to enter the middle part of the temporal muscle on its deep surface. The *posterior deep temporal nerve* springs from the masseteric nerve beneath the

upper head of the external pterygoid, and, passing upwards, it enters the posterior part of the temporal muscle on its deep surface.

The *long buccal nerve* passes outwards between the two heads of the external pterygoid, and then downwards and forwards in contact with the inner surface of the temporal muscle at its insertion. Having emerged from underneath the mandibular ramus and anterior border of the masseter, it is received upon the outer surface

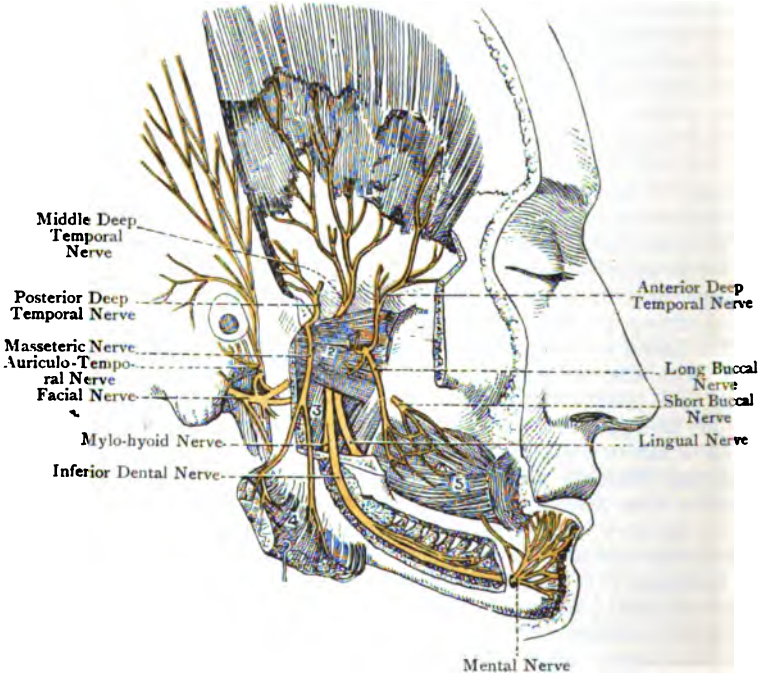


FIG. 476.—THE NERVES OF THE TEMPORAL AND PTERYGO-MAXILLARY REGIONS (HIRSCHFELD AND LEVEILLÉ).

1, Temporal Muscle; 2, External Pterygoid; 3, Internal Pterygoid; 4, Masseter; 5, Buccinator.

of the buccinator, where it communicates with the short buccal branches of the facial nerve to form the buccal plexus. Thereafter its terminal branches are distributed to the skin over the buccinator muscle and the mucous membrane which lines it. The long buccal nerve furnishes two branches, namely, the external pterygoid nerve and the anterior deep temporal nerve. The *external pterygoid nerve* is detached from it near its origin, and enters the external pterygoid muscle on its deep surface. The *anterior deep temporal nerve* arises from it after it has emerged between the two heads of the external

pterygoid. These two branches conduct away all the motor fibres from the long buccal nerve, which thereafter is entirely sensory.

Posterior Division.—This division is larger than the anterior, and is almost entirely sensory, the only motor fibres which it contains being destined for the mylo-hyoid branch of the inferior dental nerve. Its branches are three in number, namely, (1) auriculo-temporal, (2) inferior dental, and (3) lingual (gustatory).

Auriculo-temporal Nerve.—This nerve, which is sensory, arises by two roots, between which the middle meningeal artery ascends to the foramen spinosum. Thereafter the two roots join, and the nerve is directed backwards under cover of the external pterygoid muscle. Having passed close behind the temporo-mandibular joint to the interval between that joint and the auricle, it enters the upper part of the parotid gland. It then changes its course, and passes upwards through the upper part of the gland, after emerging from which it crosses the zygoma and ascends close behind the superficial temporal artery to end in its terminal temporal branches.

Branches of Communication.—(1) Each root of the auriculo-temporal nerve receives a small branch from the otic ganglion. These branches contain fibres of the glosso-pharyngeal nerve, through means of (*a*) its tympanic branch (Jacobson's nerve), (*b*) the tympanic plexus, and (*c*) the small superficial petrosal nerve, which latter is reinforced by a branch from the geniculate ganglion of the facial nerve. These glosso-pharyngeal fibres are destined for the parotid gland. (2) Two communicating branches pass to the temporo-facial division of the facial nerve in the parotid gland.

Branches of Distribution.—(1) *Articular branches* enter the temporo-mandibular joint through the back part of the capsule. (2) *Glandular branches* are distributed to the parotid gland, to which they conduct fibres of the glosso-pharyngeal nerve. (3) *Meatal branches*, upper and lower, enter the meatus auditorius externus between its cartilaginous and osseous parts, and supply the skin which lines it, the upper branch also giving twigs to the outer layer of the membrana tympani. (4) *Anterior auricular branches* are distributed to the skin of the tragus and the upper part of the outer surface of the auricle. The distribution of the meatal and auricular branches explains why pain, due to affections of the lower teeth, may be referred to the ear canal and auricle. (5) The *temporal branches* are terminal. They accompany the branches of the superficial temporal artery, and supply the skin of the temporal region as high as the vertex of the skull. They communicate with the temporal branches of the facial, and the temporal branch of the temporo-malar from the superior maxillary nerve.

Inferior Dental Nerve.—This nerve, though chiefly sensory, contains motor fibres, which, however, leave it in its mylo-hyoid branch. It passes downwards, being at first under cover of the external pterygoid muscle. After escaping from beneath that muscle, it

descends upon the spheno-mandibular ligament and internal pterygoid muscle to the inferior dental foramen, through which it passes into the inferior dental canal, after having parted with its mylo-hyoid branch. The lingual nerve is anterior and internal to it, and the inferior dental artery is posterior and external to it. Within the dental canal the nerve is accompanied by the inferior dental artery, and, having arrived at the level of the mental foramen, it terminates by dividing into two branches, mental and incisor.

Branches.—(1) The **mylo-hyoid nerve** is given off from the parent trunk just before it passes through the inferior dental foramen. It conducts away all the motor fibres from the parent trunk, and in company with the mylo-hyoid artery pierces the lower part of the spheno-mandibular ligament, and then passes downwards and forwards in the mylo-hyoid groove of the inferior maxilla. The nerve and artery are maintained in position within this groove by an expansion from the lower part of the spheno-mandibular ligament, which is attached to the lips of the groove. Thereafter the nerve passes forwards on the inferior surface of the mylo-hyoid muscle, under cover of the superficial part of the submaxillary gland. Having furnished twigs to the mylo-hyoid muscle, it terminates in the anterior belly of the digastric.

(2) The **dental branches** arise from the parent trunk, whilst it traverses the inferior dental canal. They communicate with each other to form a delicate plexus, from which branches are given off to the pulps of the lower molar and bicuspid teeth, as well as to the adjacent part of the gum. The pulp-branches correspond in number to the fangs of the teeth, and each enters through a minute opening on the extremity of the fang.

(3) The **mental nerve** is one of the two terminal branches. It emerges from the inferior dental canal through the mental foramen. For its distribution, see p. 1101.

(4) The **incisor nerve** represents the termination of the inferior dental. It commences at the level of the mental foramen, and passes almost as far as the middle line. Its dental branches communicate in a plexiform manner, and supply the pulps of the lower canine and incisor teeth, as well as the adjacent portion of the gum.

Lingual Nerve.—This nerve is sensory. It descends under cover of the external pterygoid muscle, lying anterior and internal to the inferior dental nerve. Whilst under cover of that muscle it receives near its origin the chorda tympani nerve, which joins it from behind at an acute angle, in a direction downwards and forwards, after emerging from the tympanum through the iter chordæ anterius, or canal of Huguier. After issuing from beneath the external pterygoid muscle the lingual nerve passes downwards and forwards between the internal pterygoid muscle and the mandibular ramus, and over the mandibular fibres of the superior constrictor muscle. Below the level of the third lower molar tooth it lies immediately beneath the mucous membrane of the mouth, and is

here accessible for operative purposes. Thereafter it crosses the stylo-glossus, and passes forwards over the hyo-glossus close to the side of the tongue. Upon the latter muscle it describes a slight curve with the convexity downwards. It then passes beneath the mylo-hyoid muscle, where it lies above the deep part of the submaxillary gland and Wharton's duct, and has the submaxillary ganglion suspended from it. Finally, having crossed Wharton's duct from above downwards, it continues its course as far as the tip of the tongue. As it passes along the side of the tongue the nerve is immediately beneath the mucous membrane.

Branches of Communication.—(1) *Chorda tympani*, from the facial; (2) two branches to the submaxillary ganglion; and (3) one

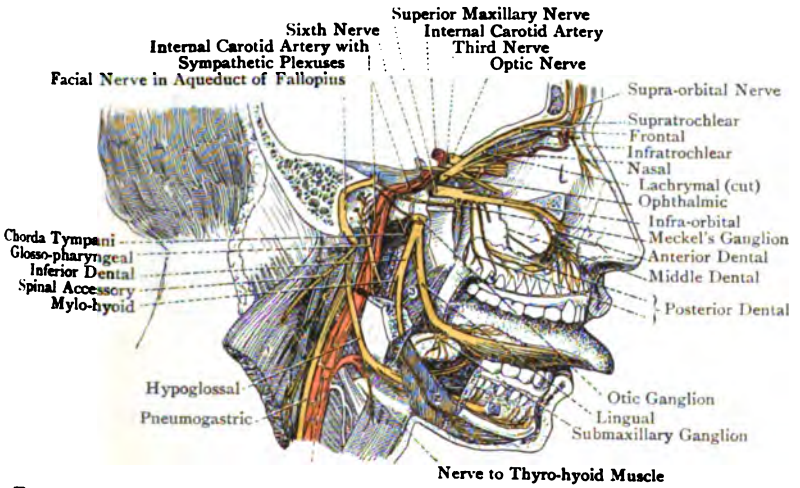


FIG. 477.—GENERAL VIEW OF THE FIFTH CRANIAL NERVE (HIRSCHFELD AND LEVEILLÉ).

1. Sterno-cleido-mastoid; 2, Mylo-hyoid; 3, Internal Pterygoid.

or two filaments to the hypoglossal nerve at the anterior border of the hyo-glossus muscle.

Branches of Distribution.—(1) *Buccal*, to the mucous membrane of the floor of the mouth and of the gums; (2) *glandular*, to the sublingual gland; and (3) *lingual*, to the mucous membrane of the sides and dorsum of the tongue over its *anterior two-thirds*. These lingual branches pierce the muscular tissue of the tongue, and are destined chiefly for the conical and fungiform papillæ.

Otic Ganglion.—The otic ganglion, or Arnold's ganglion, is a small oval body, of a pinkish colour, which is situated close to the foramen ovale, on the deep surface of the inferior maxillary nerve at the place of origin of the internal pterygoid nerve, with which it is closely connected. It has the middle meningeal artery

behind it, and the cartilaginous part of the Eustachian tube on its inner side. The ganglion has three roots. One root (motor-sensory) is derived from the internal pterygoid nerve, and conveys to the ganglion motor fibres, and probably also sensory fibres. A second root (sensory-motor) is represented by the small superficial petrosal nerve, which joins the back part of the ganglion. This root also conveys to the ganglion sensory and motor fibres. The sensory fibres come from the glosso-pharyngeal, through means of (1) the tympanic nerve or nerve of Jacobson, (2) the tympanic plexus, and (3) the small superficial petrosal. The motor fibres conveyed by this root come from the geniculate ganglion of the facial nerve, through means of the branch which that ganglion gives

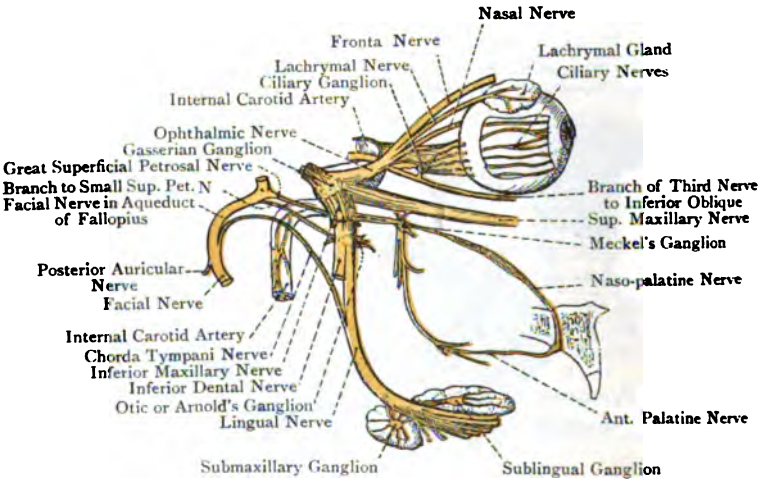


FIG. 478.—SCHEME OF THE FIFTH CRANIAL NERVE AND ITS GANGLIA (HIRSCHFELD AND LEVEILLÉ).

to join the small superficial petrosal nerve. The third root (sympathetic) comes from the sympathetic plexus around the middle meningeal artery.

Branches—(1) **Of Communication.**—(*a*) Two branches pass to the auriculo-temporal nerve, one to each root. These convey to that nerve glosso-pharyngeal fibres which are destined for the parotid gland. (*b*) A branch joins the chorda tympani. (*c*) A branch joins the Vidian nerve.

(2) **Of Distribution.**—Muscular branches are given to the tensor tympani and tensor palati.

Submaxillary Ganglion.—This ganglion is of small size, and is connected with the lingual nerve in the submaxillary region. It is situated upon the upper part of the hyo-glossus muscle, between the lingual nerve and the deep part of the submaxillary gland, and

under cover of the posterior part of the mylo-hyoid muscle. It is suspended from the lingual nerve by two connecting branches, posterior and anterior, which stand apart from each other. The posterior branch represents the combined motor and sensory roots, the motor or secretory fibres being derived from the chorda tympani of the facial, now incorporated with the lingual, and the sensory fibres coming from the lingual itself. This posterior branch may exist as two twigs. The anterior connecting branch is an offset from the ganglion to join the lingual. The sympathetic root of the ganglion is derived from the plexus on the cervical portion of the facial artery.

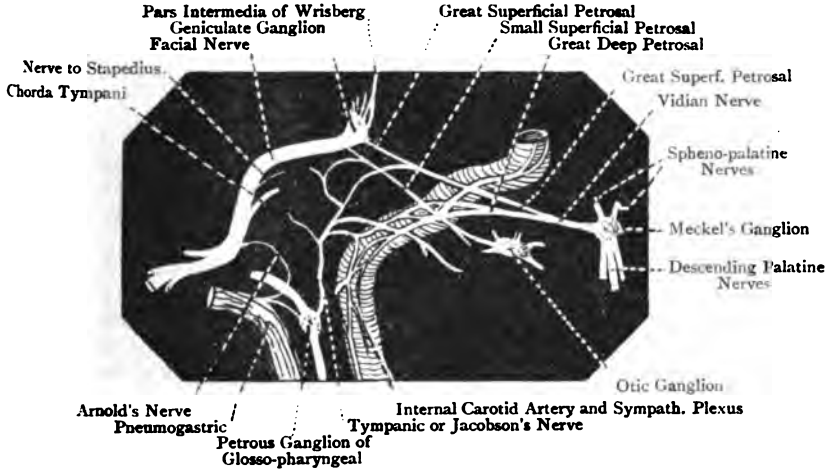


FIG. 479.—THE FACIAL NERVE IN THE AQUEDUCT OF FALLOPIUS, ETC. (HIRSCHFELD AND LEVEILLÉ).

Roots of the Submaxillary Ganglion.

Motor or Secretory.	Sensory.	Sympathetic.
From chorda tympani of facial.	From lingual.	From plexus on cervical portion of facial artery.

Branches.—These proceed from the lower and anterior parts of the ganglion, and are as follows: (1) glandular to the submaxillary gland; (2) branches to Wharton's duct; (3) buccal to the mucous membrane of the floor of the mouth; and (4) an anterior connecting branch, which passes to the lingual nerve. The anterior connecting branch probably consists of both chorda tympani and lingual fibres, and it accompanies the lingual nerve to the tongue. It furnishes twigs to the sublingual gland, and a small ganglion associated with these twigs has been described under the name of the sublingual ganglion.

Summary of the Inferior Maxillary Nerve—1. **Cutaneous Distribution.**—It supplies (1) a portion of the dura mater, and the mucous membrane of the mastoid cells; (2) the skin over the greater part of the temporal region; (3) the skin of the external auditory meatus, and the outer surface of the membrana tympani; (4) the skin of the tragus, and of the upper part of the outer surface of the auricle; (5) the skin over the body of the inferior maxilla, including the skin of the chin and lower lip, as well as the mucous membrane of the lower lip; (6) the mucous membrane of the floor of the mouth, and the lower gum; and (7) the sides and dorsum of the tongue over its anterior two-thirds. 2. **Articular Distribution.**—It supplies the temporo-mandibular joint. 3. **Dental Distribution.**—It supplies the pulps of all the lower teeth of one side, and the mucous membrane of the outer surface of the lower gum of one side. 4. **Glandular Distribution.**—It gives branches to the parotid, submaxillary, and sublingual glands. 5. **Muscular Distribution.**—It supplies (1) the muscles of mastication, namely, the masseter, temporal, external pterygoid and internal pterygoid; (2) the mylo-hyoid and anterior belly of the digastric; and (3) the tensor palati and tensor tympani.

The Temporo-mandibular Joint.

The temporo-mandibular (temporo-maxillary) joint belongs to the class **diarthrosis,** and to the subdivision **condylarthrosis.** The articular surfaces are (1) the anterior part of the glenoid fossa, in front of the fissure of Glaser, and (2) the condyle of the mandible or inferior maxilla.

Ligaments.—These are as follows: the external lateral, capsular, internal lateral, stylo-mandibular, and interarticular fibro-cartilage.

The **external lateral ligament** is a short strong bundle of fibres, which is attached above to the tubercle and adjacent portions of the outer surface and lower border of the zygoma, and below to the condylar tubercle and the outer and back part of the neck of the mandible. Its fibres are directed obliquely downwards and backwards. This ligament forms the external portion of the capsular ligament.

The **capsular ligament** consists of scattered fibres which form a thin loose investment to the joint on its anterior, internal, and posterior aspects, being completed on the outer aspect by the external lateral ligament.

The **internal lateral,** or **spheno-mandibular, ligament** is a long flat band, which stands off from the joint, and therefore has no direct relation to it. It is somewhat triangular, being narrow above and broad below. Superiorly it is attached to the spinous process of the sphenoid bone, and inferiorly to the lingula and the inner margin of the inferior dental foramen of the mandible. Its fibres are directed downwards and slightly forwards. Superiorly it is covered by the external pterygoid muscle; subsequently the first part of the internal maxillary artery rests upon it, and separates it from the neck of the mandible; and inferiorly the inferior dental vessels and nerve and the auriculo-temporal nerve intervene between it and the ramus of the mandible. At its lower attachment it is spread over the upper end of the mylo-hyoid groove, and is here pierced by the mylo-hyoid nerve and artery. This ligament is

sometimes spoken of as the *long internal lateral ligament*, in contradistinction to the internal portion of the capsule, which is regarded as the *short internal lateral ligament*.

The spheno-mandibular ligament represents a portion of the fibrous investment of Meckel's cartilage.

The **stylo-mandibular ligament** is a stout process of the deep cervical fascia, which extends from the styloid process of the temporal bone near its tip to the angle and adjacent portion of the posterior border of the ramus of the mandible. Superiorly it gives origin to a few fibres of the styloglossus, and inferiorly it is implanted between the masseter and internal pterygoid muscles. It separates the submaxillary gland from the lower portion of the parotid gland.

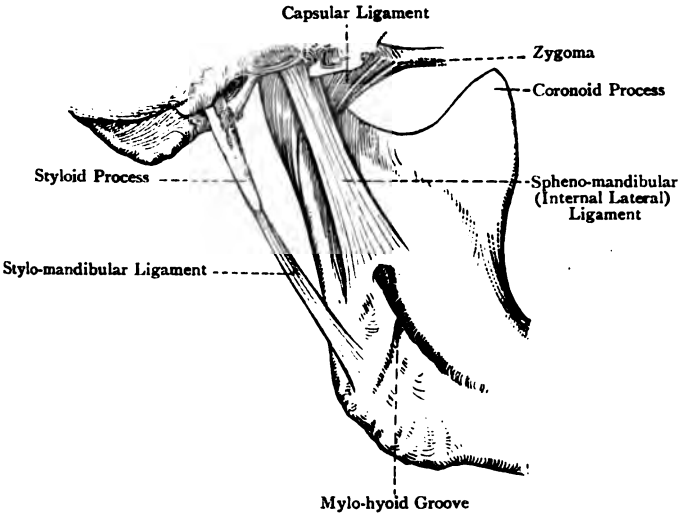


FIG. 480.—THE TEMPORO-MANDIBULAR JOINT (INTERNAL VIEW).

The **interarticular fibro-cartilage** is an oval plate which is interposed between the two articular surfaces. It is thinnest at the centre, where it is occasionally perforated, and thickest posteriorly. Its superior surface is concavo-convex from before backwards, in adaptation to the convexity of the eminentia articularis and the concavity of the glenoid fossa. Its inferior surface is concave, and fits upon the condyle of the mandible. Its circumference is connected with the capsular ligament, and anteriorly it gives partial insertion to the external pterygoid muscle. It divides the joint into two compartments, upper and lower, which are usually distinct.

The **synovial membranes** are two in number, upper and lower, one being above and the other below the plate of fibro-cartilage. The upper synovial membrane is larger and looser than the lower,

and, when the plate of fibro-cartilage is perforated at the centre, the two synovial membranes are continuous through the perforation.

Arterial Supply.—The superficial temporal artery chiefly.

Nerve-supply.—The auriculo-temporal nerve and offsets from the masseteric nerve.

Movements.—These are as follows: (1) depression, (2) elevation, (3) protraction, (4) retraction, and (5) lateral movements. There being two divisions of the joint, upper and lower, different movements occur in each. The movement in the *upper compartment* is of a **gliding** character, whilst in the *lower compartment* it is of a **ginglymoid** or **hinge character**. When the mandible is depressed, as in opening the mouth, the condyle and the plate of fibro-cartilage move forwards on to the eminentia articularis. In cases of over-depression, as in violent yawning, or forcing too large a body into the mouth, the condyle is apt to slip over the eminentia articularis into the zygomatic fossa, and, when this takes place, dislocation of the mandible is the result.

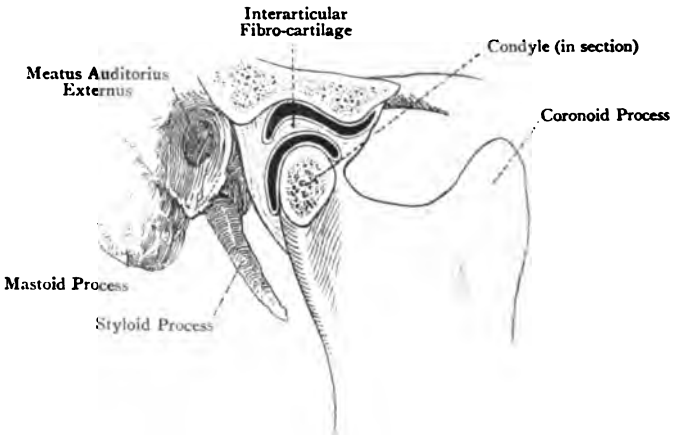


FIG. 481.—THE TEMPORO-MANDIBULAR JOINT OPENED (EXTERNAL VIEW).

The movement of forward gliding on the part of the condyle and plate of fibro-cartilage during depression takes place in the upper compartment of the joint. Another movement, however, of a ginglymoid or hinge character is taking place in the lower compartment of the joint, namely, between the condyle and the interarticular plate. This consists in the condyle rotating on the under surface of the plate round a transverse axis.

When the mandible is elevated, as in shutting the mouth, the changes which occur in both compartments of the joint are the reverse of those just described as taking place in depression. The condyle and fibro-cartilage glide backwards into the glenoid cavity, and at the same time the condyle rotates back to its previous position. In protraction, as when the lower incisors are protruded beyond the upper, and in retraction, the movement mainly takes place in the upper compartment of the joint, and consists in the condyle and plate of fibro-cartilage gliding forwards and backwards. When these movements are performed alternately on each side the lateral oblique movements, as in grinding or chewing, take place, and the condyle and fibro-cartilage of one side move forwards and backwards, whilst the other condyle and fibro-cartilage move in the opposite direction. During these movements **oblique rotation** is taking place in the lower compartment of the joint.

Muscles Concerned in the Movements. — **Depression** is effected by the platysma myoides, mylo-hyoid, anterior belly of the digastric, and genio-hyoid muscles; and **elevation** by the anterior fibres of the temporal, masseter, and internal pterygoid muscles. **Protraction** is produced by the external pterygoid, the superficial fibres of the masseter, and slightly by the internal pterygoid; and **retraction** by the posterior fibres of the temporal, and the deep fibres of the masseter. The **grinding movement** is effected by the external pterygoid muscles acting alternately.

The Superior Maxillary Nerve.

The superior maxillary nerve is the second division of the fifth cranial nerve, and in size is intermediate between the inferior maxillary and the ophthalmic. It is entirely sensory, and arises from the Gasserian ganglion. Its course is forwards to the foramen rotundum, by which it leaves the cranial cavity. Thereafter it enters the posterior part of the spheno-maxillary fossa, and then crosses the upper part of that fossa to the spheno-maxillary fissure, through which it passes on to the floor of the orbit. It now takes on the name of the **infra-orbital nerve,** and traverses the infra-orbital groove, and then the infra-orbital canal, on the floor of the orbit. Finally, it emerges from this canal through the infra-orbital foramen, under cover of the levator labii superioris, and ends in its terminal branches. The course of the superior maxillary nerve (and its continuation under the name of the infra-orbital nerve) is almost directly forwards, there being a slight inclination outwards.

Branches.—These are as follows:

Intracranial.	**In Infra-orbital Canal.**
Recurrent meningeal.	Middle superior dental.
	Anterior superior dental.
In Spheno-maxillary Fossa.	**Facial.**
Orbital or temporo-malar.	Inferior palpebral.
Spheno-palatine.	Lateral nasal.
Posterior superior dental.	Superior labial.

The **recurrent meningeal branch** supplies the dura mater of the middle cranial fossa.

The **orbital** or **temporo-malar nerve** is the first branch of the superior maxillary in the spheno-maxillary fossa. It arises from its upper surface, and enters the orbit through the spheno-maxillary fissure. For its further course, see p. 1082.

The **spheno-palatine nerves** are two in number. They arise from the lower aspect of the parent trunk, and, after a very short descending course, they end for the most part in Meckel's ganglion, to which they convey sensory fibres, and of which they are the sensory roots. Many of their fibres, however, pass clear of the grey matter of the ganglion, and are prolonged into the nasal and descending palatine branches of the ganglion.

The **posterior superior dental nerve** arises from the superior maxillary as it is about to pass through the spheno-maxillary fissure, and soon divides into two branches, which sometimes arise separately. They descend in grooves on the zygomatic surface of the superior maxilla, in company with branches of the posterior dental artery, and give off branches to the gum and contiguous part of the mucous membrane of the cheek. Thereafter they traverse the posterior dental canals, and within the substance of the bone they communicate with each other and with the middle superior dental nerve to form a delicate plexus, from which branches are given off to the pulps of the three upper molar teeth. Slender filaments are also furnished to the mucous membrane lining the antrum of Highmore.

The **middle superior dental nerve** arises from the main trunk as it lies in the infra-orbital groove near the spheno-maxillary fissure. It descends, in company with the middle dental artery, in the middle dental canal of the superior maxilla. Its branches communicate with each other, and with the posterior superior and anterior superior dental nerves within the substance of the bone, to form a delicate plexus, from which branches are given to the pulps of the upper two bicuspid teeth and to the gum. This nerve also furnishes delicate filaments to the mucous membrane lining the antrum of Highmore. Two enlargements are described in connection with the middle superior dental nerve. One is situated at its communication with the posterior superior dental nerve, and is known as the *ganglion of Valentin ;* and the other at its communication with the anterior superior dental, this one being known as the *ganglion of Bochdalek.*

The **anterior superior dental nerve** arises from the infra-orbital nerve near the front part of the infra-orbital canal, and descends, in company with the anterior dental artery, in the anterior dental canal. Its branches communicate with each other and with the middle superior dental nerve to form a delicate plexus, from which branches are given to the pulps of the upper canine and incisor teeth. This nerve also furnishes delicate filaments to the mucous membrane lining the antrum of Highmore, and a nasal branch, which enters the nasal fossa and supplies the mucous membrane of the anterior part of the inferior meatus and adjacent portion of the inferior concha.

The **facial branches** of the infra-orbital nerve, namely, inferior palpebral, lateral nasal, and superior labial, have been already described, see p. 1101.

It is to be noted that there are three superior dental nerves, right and left, the *posterior* being a branch of the superior maxillary, and the *middle* and *anterior* being branches of the infra-orbital; whilst there is only one inferior dental nerve, which is a branch of the inferior maxillary.

Spheno-palatine Ganglion.—This is also called **Meckel's ganglion.** It is a small triangular, somewhat reddish body, situated in the

upper part of the spheno-maxillary fossa, close to the spheno-palatine foramen, which leads through the inner wall of the fossa to the superior meatus of the nasal fossa. It is suspended from the superior maxillary nerve by some of the fibres of the two spheno-palatine branches of that nerve, many fibres of these two branches, as stated, passing clear of the grey matter of the ganglion into its nasal and descending palatine branches. The fibres conveyed to the grey matter of the ganglion by the two spheno-palatine nerves represent its *sensory root* or *roots*. The *motor* and *sympathetic roots* are combined, and form the **Vidian nerve,** which joins the back part of the ganglion. The Vidian nerve

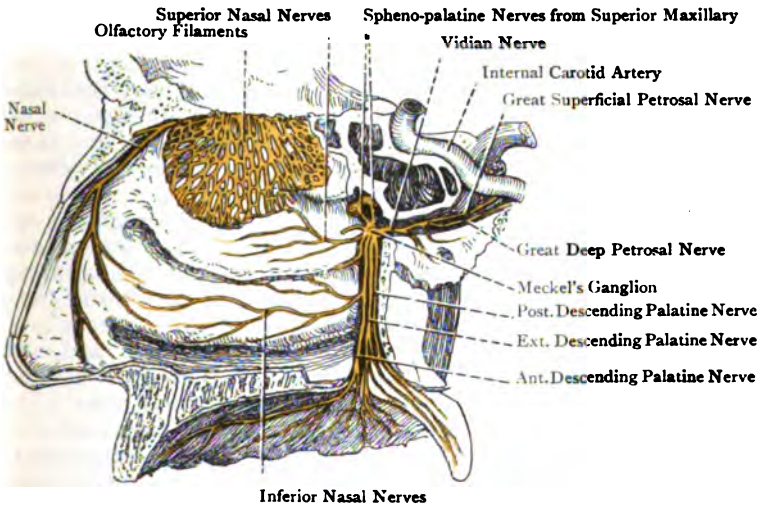


FIG. 482.—NERVES OF THE NASAL FOSSA, AND THE SPHENO-PALATINE OR MECKEL'S GANGLION, WITH ITS BRANCHES (INTERNAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

is formed in the foramen lacerum medium by the junction of the great superficial petrosal nerve from the geniculate ganglion of the facial, and the great deep petrosal from the carotid plexus of the sympathetic. The great superficial petrosal nerve, though largely composed of sensory fibres, related to the pars intermedia of Wrisberg, also contains motor fibres, and so represents the motor root of Meckel's ganglion. The Vidian nerve traverses the Vidian canal from behind forwards, and thus enters the spheno-maxillary fossa, where it joins the back part of the ganglion. In the Vidian canal the Vidian nerve gives off one or two nasal branches, which pass through the floor of the canal, and are distributed to the mucous membrane of the posterior part of the roof of the nasal fossa and adjacent part of the septum.

Branches of the Spheno-palatine Ganglion.—These are arranged in four sets, and are as follows :

Ascending.	Posterior.	Internal.	Descending.
Orbital.	Pharyngeal or pterygo-palatine. Vidian.	Superior nasal. Naso-palatine.	Great or anterior palatine. Small or posterior palatine. External palatine.

Ascending Branches. — These are called the **orbital branches**. They are two or three in number, and enter the orbit through the spheno-maxillary fissure, to be distributed to the periosteum. They have been described by Luschka as sending filaments through the inner wall of the orbit to supply the mucous membrane of the posterior ethmoidal cells and the sphenoidal air-sinus.

Posterior Branches.—These are the pharyngeal and the Vidian nerves. The **pharyngeal nerve** passes backwards in the pterygo-palatine canal, along with the pterygo-palatine artery, and is distributed to the mucous membrane of the upper part of the pharynx in the region of the Eustachian orifice.

The **Vidian nerve** (just described), if it is to be regarded as a posterior branch of the ganglion, establishes a communication between it and (1) the geniculate ganglion of the facial, through means of the great superficial petrosal, and (2) the carotid plexus of the sympathetic, through means of the great deep petrosal.

Internal Branches.—These are the superior nasal and naso-palatine nerves. The **superior nasal nerves** are of small size, and derive some of their fibres from the spheno-palatine nerves. They are about six in number, and, springing from the inner part of the ganglion, they enter the superior meatus of the nose through the spheno-palatine foramen. They supply the mucous membrane of the superior and middle conchæ, the superior meatus, the posterior ethmoidal cells, the middle meatus, and the upper and back part of the septum.

The **naso-palatine nerve** (*nerve of Cotunnius*) enters the nasal fossa along with the superior nasal nerves. It crosses the roof of the fossa, and then passes downwards and forwards upon the septum, lying in the groove on the lateral surface of the vomer. Having arrived at the region of the incisor crest, the **left** naso-palatine nerve descends through the *anterior* foramen or canal of Scarpa, and the right descends through the posterior. Having reached the anterior palatine fossa in this manner, the two nerves communicate in a plexiform manner, and delicate filaments are furnished to the mucous membrane of the hard palate behind the incisor teeth. In this situation communications are established with the great or anterior descending palatine nerve of each side. As the naso-palatine nerve traverses the groove on the lateral surface of the vomer, it furnishes twigs to the mucous membrane of the nasal septum, and in this part of its course it is accompanied by the naso-

palatine artery (artery of the septum); but this artery does not accompany it through the foramen or canal of Scarpa.

Descending Branches.—These are the great or anterior, the small or posterior, and the external palatine nerves. They arise from the lower part of the ganglion, usually by a common trunk, and they derive some of their fibres from the spheno-palatine nerves.

The **great** or **anterior palatine nerve** descends in the posterior palatine canal, and escapes from it through the posterior palatine foramen. Thereafter it divides into branches which pass forwards and inwards, occupying grooves on the hard palate, to the mucous membrane and glands of which, as well as to the mucous membrane of the upper gum on its inner aspect, they are distributed. In the region of the anterior palatine fossa this nerve communicates with the naso-palatine nerve. As it descends in the posterior palatine canal, it furnishes **two inferior nasal nerves,** which enter the nasal fossa, and are distributed to the mucous membrane over the inferior concha, except anteriorly, and to that of the adjacent portion of the inferior meatus. The **small** or **posterior palatine nerve** descends in the posterior accessory palatine canal, after emerging from which it is distributed to the mucous membrane of the soft palate and tonsil. It may furnish branches to the levator palati and azygos uvulæ muscles, the fibres of these branches being derived from the geniculate ganglion of the facial through means of the great superficial petrosal, which contributes to the formation of the Vidian nerve, and conveys motor fibres to Meckel's ganglion. The two muscles in question, however, are most probably supplied by the bulbar part of the spinal accessory nerve through the pharyngeal plexus. The **external palatine nerve** descends through the external accessory palatine canal, after emerging from which it is distributed to the mucous membrane of the outer portion of the soft palate and tonsil.

Summary of the Superior Maxillary Nerve and Meckel's Ganglion—1. **Cutaneous Distribution.**—(1) The skin of the anterior part of the temporal region, and over the malar bone; (2) the skin from the lower eyelid down to the upper lip, including the skin of the side of the nose; (3) the mucous membrane of the naso-pharynx in the vicinity of the Eustachian orifice; (4) the mucous membrane of the nasal fossa; (5) the mucous membrane of the antrum of Highmore; (6) the mucous membrane of the soft palate and tonsil; and (7) the mucous membrane of the hard palate, with its glands, and that of the inner surface of the upper gum. 2. **Dental Distribution.**—The pulps of all the upper teeth of one side, as well as the mucous membrane of the outer surface of the upper gum.

In addition to the foregoing, the superior maxillary nerve supplies the periosteum of the orbit, and the dura mater of the middle cranial fossa.

Deep Dissection of the Neck.

Stylo-pharyngeus—*Origin.*—The base of the styloid process of the temporal bone on its inner aspect.

Insertion.—(1) The superior and posterior borders of the ala of the thyroid cartilage, and (2) the lateral wall of the pharynx, its

fibres blending with those of the palato-pharyngeus and middle constrictor muscles.

Nerve-supply.—The glosso-pharyngeal nerve.

The muscle is directed downwards and inwards.

Action.—To elevate the pharynx and larynx.

The muscle passes between the superior and middle constrictor muscles. The glosso-pharyngeal nerve lies at first along its lower border, and then crosses over it on its way to the posterior part of the tongue.

Internal Carotid Artery.—The internal carotid artery is one of the terminal branches of the common carotid. It commences on a level with the upper border of the thyroid cartilage, and passes vertically upwards to the under surface of the petrous part of the temporal bone. Here it enters the carotid canal within the *pars petrosa*, and, after traversing this canal, it enters the cranial cavity. The vessel is divided into three parts—extracranial or cervical, petrous, and intracranial or cavernous.

Extracranial or Cervical Part.—This part of the vessel extends from the level of the upper border of the thyroid cartilage to the foramen caroticum on the inferior surface of the petrous part of the temporal bone. Its course is vertically upwards, and at first it lies in the carotid triangle, where it is placed external to, and behind, the external carotid artery.

Relations—*Anterior.*—This part of the vessel is comparatively superficial, being covered by the integument, platysma myoides, and sterno-cleido-mastoid, the latter overlapping it. After leaving the carotid triangle the artery becomes deeply placed, and passes beneath the posterior belly of the digastric and stylo-hyoid muscles, parotid gland, styloid process, and stylo-pharyngeus muscle. In this part of its course the vessel is crossed by the hypoglossal, glosso-pharyngeal, and pharyngeal branch of the pneumogastric, nerves, and by the occipital and posterior auricular arteries. The relation of the artery to the external carotid here undergoes a change. The level where the change takes place is as the internal carotid passes beneath the styloid process of the temporal bone, and the change consists in the external carotid taking up a position directly anterior to the internal carotid. The two arteries are, however, separated from each other by the following structures: (1) the styloid process; (2) the stylo-pharyngeus muscle; (3) the glosso-pharyngeal nerve; and (4) the pharyngeal branch of the pneumogastric nerve.

Posterior.—The rectus capitis anticus major, the superior cervical ganglion of the sympathetic, and the superior laryngeal branch of the pneumogastric nerve.

External.—The internal jugular vein and pneumogastric nerve, the nerve being on a plane posterior to both artery and vein. These three structures are still surrounded by a sheath which is an upward extension of the carotid sheath, previously described. Close to the base of the skull the glosso-pharyngeal, spinal accessory, and hypo-

glossal nerves lie between the internal carotid artery and the internal jugular vein. The glosso-pharyngeal nerve soon passes forwards superficial to the artery, the spinal accessory nerve passes backwards superficial to the vein, and the hypoglossal nerve passes forwards superficial to the artery at the lower border of the posterior belly of the digastric muscle.

Internal.—The ascending pharyngeal artery, the lateral wall of the pharynx, the tonsil, and the superior laryngeal nerve.

Development.—The internal carotid artery is developed from the third arterial arch and the part of the dorsal aorta above it (see p. 940).

The Glosso-pharyngeal Nerve.

The glosso-pharyngeal or ninth cranial nerve is a mixed nerve, consisting of both afferent or sensory and efferent or motor fibres. It emerges from the cranial cavity through the middle compartment of the jugular foramen, along with the pneumogastric and spinal accessory nerves, but enclosed in a separate sheath of the dura mater, and lying on the outer side of, and anterior to, these two nerves. In passing through the jugular foramen, the nerve presents two ganglia, the upper one, which is small and situated in the upper part of the foramen, being called the jugular ganglion ; and the lower one, which is rather larger, being called the petrous ganglion. The latter is about $\frac{1}{4}$ inch in length, and lies in the lower part of the foramen, where it occupies a groove on the petrous portion of the temporal bone. After emerging from the jugular foramen, the nerve at first descends between the internal carotid artery and internal jugular vein, being external to the line of the pneumogastric nerve. It then passes downwards and forwards in front of the internal carotid artery, and under cover of the styloid process, stylo-pharyngeus muscle, and external carotid artery. It next curves round the lower border of the stylo-pharyngeus, and crosses its superficial surface in a forward direction. Finally, it passes beneath the hyo-glossus muscle, and so reaches the posterior third of the tongue, where it divides into its terminal branches.

The **jugular ganglion,** as stated, is very small, and involves only a few of the fibres of the nerve, the other fibres passing clear of, but close to, the ganglion, and being continued into the nerve beyond it. This ganglion neither gives nor receives any branches, and is sometimes absent.

The **petrous ganglion,** unlike the jugular, involves all the fibres of the nerve, and it furnishes connecting branches and the tympanic nerve.

Branches of the Glosso-pharyngeal Nerve—1. **From the Petrous Ganglion**—(*a*) *Branches of Communication.*—These are three in number, as follows : one to the superior cervical ganglion of the sympathetic ; one to the auricular branch of the ganglion of the root of the pneumogastric ; and one to the ganglion of the root of the pneumogastric.

(*b*) *Branch of Distribution.*—This is called the *tympanic nerve*, or *nerve of Jacobson*. After leaving the petrous ganglion, it ascends, in company with the tympanic branch of the ascending pharyngeal artery, through the tympanic canaliculus. In this way it enters the tympanic cavity at the junction of the inner wall and floor, and ascends upon the inner wall. Being joined by the caroticotympanic branch of the carotid plexus of the sympathetic, it breaks up into branches which occupy grooves upon the promontory, and form the tympanic plexus. From this plexus the tympanic nerve emerges under the name of the small superficial petrosal nerve, which leaves the tympanic cavity and traverses a minute canal in the petrous bone, passing in its course beneath the upper portion of the canal which lodges the tensor tympani muscle. Whilst in this canal, it is joined by a communicating branch from the geniculate ganglion of the facial nerve. It emerges from the canal through the accessory hiatus on the superior surface of the petrous bone, which is external to the hiatus Fallopii, and then passes forwards and inwards beneath the dura mater. Thereafter it passes through the canaliculus innominatus, when present, or through the fissure between the *pars petrosa* and great wing of the sphenoid, or sometimes through the foramen ovale, into the zygomatic fossa, where it joins the otic ganglion, to which it conducts glosso-pharyngeal and facial fibres.

For a description of the tympanic plexus, see p. 1420.

2. **From the Trunk of the Nerve.**—(1) A *communicating branch* sometimes passes from the nerve a little below the petrous ganglion to join the digastric branch of the facial nerve. (2) A *carotid branch* passes to the sympathetic plexus on the internal carotid artery. (3) *Pharyngeal Branches.*—These are about four in number. Three of them unite, over the middle constrictor of the pharynx, with the subdivisions of the pharyngeal branch of the ganglion of the trunk of the pneumogastric, and with branches of the superior cervical ganglion of the sympathetic, to form the pharyngeal plexus. The other pharyngeal branch pierces the superior constrictor, and is distributed to the mucous membrane of the upper part of the pharynx. (4) A *muscular branch* to the stylo-pharyngeus muscle, some of the fibres of which pierce the muscle to supply the mucous membrane of the pharynx. (5) *Tonsillar branches* are given off near the tongue, which are distributed to the tonsil and the anterior and posterior pillars of the fauces. (6) *Lingual or Glossal Branches.*—Under cover of the hyo-glossus muscle, the terminal part of the nerve divides into two branches, dorsal and lateral. The *dorsal branch* passes to the dorsum of the tongue, and is distributed to the circumvallate papillæ and the mucous membrane over the posterior third, extending as far back as the front of the epiglottis. The *lateral branch* is distributed to the mucous membrane of the side of the tongue over about its posterior half.

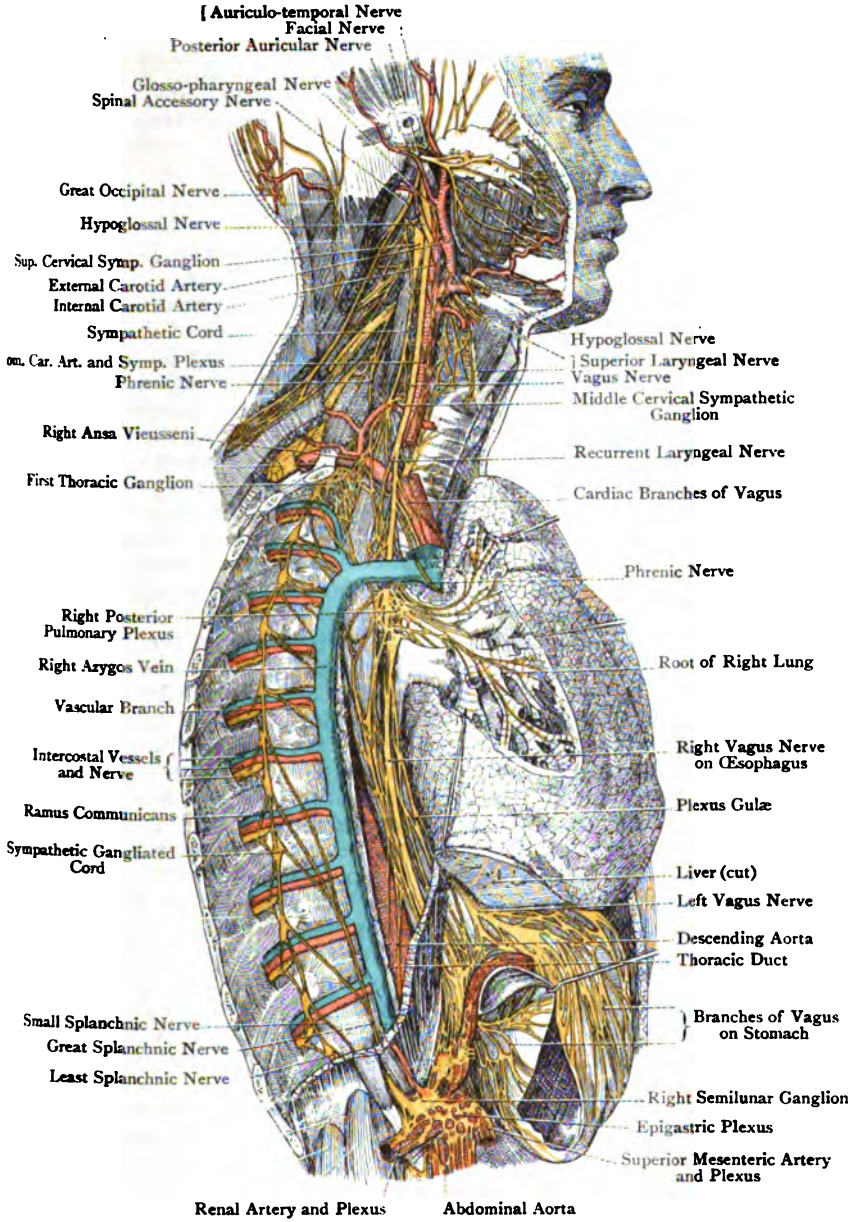


FIG. 483.—NERVES OF THE RIGHT SIDE OF THE FACE, NECK, AND THORAX (HIRSCHFELD AND LEVEILLÉ).

Summary of the Glosso-pharyngeal Nerve—1. **Cutaneous Distribution.**—It supplies (*a*) the mucous membrane of the tympanum, the posterior third of the tongue, the pillars of the fauces, and the pharynx; and (*b*) the tonsil. 2. **Muscular Distribution.**—It supplies the stylo-pharyngeus. 3. **Glandular Distribution.**—Through means of (1) its tympanic, subsequently small superficial petrosal, branch, (2) the otic ganglion, and (3) the auriculo-temporal nerve, it furnishes secretory branches to the parotid gland.

The Pneumogastric Nerve.

The pneumogastric (vagus) or tenth cranial nerve is a mixed nerve, consisting of both afferent and efferent fibres. It emerges from the cranial cavity through the middle compartment of the jugular foramen, being enclosed in the same sheath of dura mater as the spinal accessory, and, with that nerve, lying on the inner side of, and slightly posterior to, the glosso-pharyngeal. In the foramen it presents a small enlargement, called the ganglion of the root. After emerging from the foramen, it is joined by the accessory portion of the spinal accessory nerve, and it here presents another enlargement, called the ganglion of the trunk. This ganglion is larger and longer than that of the root, measuring fully $\frac{3}{4}$ inch in length, and presenting a somewhat plexiform appearance. In this part of its course the nerve lies between the internal carotid artery and the internal jugular vein, the glosso-pharyngeal nerve being in front of it, and the spinal accessory behind it. The hypoglossal nerve lies at first deeply behind it, but subsequently turns round the outer side of the ganglion of the trunk. The pneumogastric then descends within the carotid sheath, lying at first between the internal carotid artery and the internal jugular vein, and then between the common carotid artery and the internal jugular vein, being on a plane posterior to both vessels. Within the sheath the nerve occupies a special compartment, situated in the back part of the septum which separates the artery from the vein. Beyond the root of the neck the right and left nerves present important differences in their course and relations (see p. 907).

Branches—A. **Ganglion of the Root**—1. **Branches of Communication.**—(*a*) It receives two filaments from the bulbar or accessory portion of the spinal accessory nerve. (*b*) It communicates by a small twig with the petrous ganglion of the glosso-pharyngeal nerve. (*c*) It communicates with the facial, and with the posterior auricular branch of the facial, through means of its auricular branch of distribution (Arnold's nerve). (*d*) It receives a twig from the superior cervical ganglion of the sympathetic.

2. **Branches of Distribution.**—(*a*) The *meningeal branch* takes a recurrent course, and, after entering the cranial cavity, supplies the dura mater which lines the cerebellar fossa of the occipital bone. (*b*) The *auricular branch*, or *nerve of Arnold*, is of small size, and is soon reinforced by a twig from the petrous ganglion of the glosso-pharyngeal. It enters the auricular canaliculus through an aperture on the posterior part of the outer wall of the jugular fossa. In this

canaliculus it traverses the petrous portion of the temporal bone, crossing in its course the inner aspect of the descending portion of the aqueduct of Fallopius a little above the stylo-mastoid foramen, where it forms its first communication with the facial nerve. It then emerges from the *pars petrosa* through the auricular or tympano-mastoid fissure, between the mastoid process and the tympanic plate, and thereafter divides into two branches. One of these joins the posterior auricular branch of the facial nerve, and the other is distributed to (*a*) the skin of the inner surface of the auricle, and (*b*) the skin of the lower and back part of the external auditory meatus.

B. **Ganglion of the Trunk**—1. **Branches of Communication.**—(*a*) The most important branch of communication is the *bulbar* or *accessory portion of the spinal accessory nerve*, which passes over the surface of the ganglion in intimate contact with it. Most of the bulbar fibres are continued into the pharyngeal and superior laryngeal nerves, but some of them descend in the main trunk of the pneumogastric, and pass into its cardiac and inferior laryngeal branches. The bulbar fibres are to be regarded as of two kinds, namely, *motor*, for the muscles of the soft palate, pharynx, and larynx, and *cardiac inhibitory*. (*b*) Branches pass between the ganglion of the trunk and the hypoglossal nerve. (*c*) A communicating branch is received from the superior cervical ganglion of the sympathetic.

2. **Branches of Distribution.**—These are two in number, namely, pharyngeal and superior laryngeal.

The **pharyngeal nerve** arises from the upper part of the ganglion of the trunk, its fibres being chiefly derived from the bulbar or accessory portion of the spinal accessory nerve. It passes forwards and downwards over the internal carotid artery, and divides into branches opposite the middle constrictor muscle, which join the pharyngeal branches of the glosso-pharyngeal and superior cervical ganglion of the sympathetic to form the pharyngeal plexus.

The **pharyngeal plexus** is situated upon the middle constrictor muscle of the pharynx. It is formed by (1) the pharyngeal branch of the ganglion of the trunk of the pneumogastric; (2) the pharyngeal branches of the glosso-pharyngeal; and (3) the pharyngeal branches of the superior cervical ganglion of the sympathetic.

Branches.—These are distributed to (1) the constrictor muscles of the pharynx; (2) the mucous membrane of the pharynx; and (3) the palato-glossus, palato-pharyngeus, levator palati, and azygos uvulæ muscles. Branches of communication pass between the plexus and the superior laryngeal and external laryngeal nerves, and another branch, known as the *lingual branch of the vagus*, passes to the hypoglossal nerve.

Superior Laryngeal Nerve.—This nerve, which is principally sensory, arises from the ganglion of the trunk of the pneumogastric near its centre, and contains fibres of the bulbar or accessory portion of the spinal accessory nerve. It passes downwards and

forwards behind the internal carotid artery, having previously received communicating branches from the superior cervical ganglion of the sympathetic and from the pharyngeal plexus. As it passes behind the internal carotid artery, it divides into two branches, internal and external. The **internal laryngeal nerve,** which is sensory, passes forwards, in company with the superior laryngeal branch of the superior thyroid artery, to the thyro-hyoid membrane, which it pierces under cover of the posterior border of the thyro-hyoid muscle. Having reached the interior of the larynx, it divides into branches which supply the mucous membrane of the epiglottis, with its folds, the mucous membrane of the larynx as low as the true vocal cords, and that covering the lateral and posterior portions of the cricoid cartilage. One branch descends over the inner surface of the ala of the thyroid cartilage, and joins a branch of the inferior or recurrent laryngeal. The **external laryngeal nerve,** of small size, descends beneath the sterno-thyroid muscle to the crico-thyroid muscle, which it supplies. It furnishes some twigs to the inferior constrictor, and a filament which joins the superior cardiac branch of the sympathetic. It receives a communicating branch from the superior cervical ganglion of the sympathetic, and one or two branches from the pharyngeal plexus.

Inferior or Recurrent Laryngeal Nerve.—This nerve is mainly motor, and is the principal motor nerve of the intrinsic muscles of the larynx. It contains fibres of the bulbar or accessory portion of the spinal accessory nerve. The *right* nerve arises from the pneumogastric at the root of the neck in front of the first part of the subclavian artery, round the lower border of which it bends, and then ascends behind it. Thereafter it passes upwards and inwards behind the carotid sheath and inferior thyroid artery to the groove between the trachea and the œsophagus. The *left* nerve arises in the thorax from the pneumogastric in front of the arch of the aorta, on a level with its lower border. It passes backwards within the arch at the place of attachment of the ligamentum ductûs arteriosi, and then it turns upwards behind the arch. Having reached the groove between the trachea and the œsophagus, it ascends therein to the neck. The right and left nerves pass upwards in the groove between the trachea and the œsophagus, on each side, lying behind the corresponding inferior thyroid artery. At the level of the cricoid cartilage each nerve passes beneath the lower border of the inferior constrictor muscle, and enters the larynx behind the crico-thyroid joint.

Extralaryngeal Branches.—(1) *Communicating twigs* pass between the recurrent laryngeal nerve and the inferior cervical ganglion of the sympathetic; (2) *cardiac branches*, which contain bulbar fibres from the spinal accessory, are furnished to the deep cardiac plexus; (3) *tracheal* and *œsophageal branches* are supplied to these tubes; and (4) *muscular offsets* pass to the lower part of the inferior constrictor.

Intralaryngeal Branches.—These are chiefly *muscular*, and supply

the intrinsic muscles of the larynx, except the crico-thyroid, which is supplied by the external laryngeal nerve. *Sensory branches*, however, are given to the laryngeal mucous membrane below the true vocal cords, except over the lateral and posterior portions of the cricoid cartilage. Within the larynx the nerve communicates with a branch of the internal laryngeal nerve, under cover of the lower part of the ala of the thyroid cartilage.

For the explanation of the recurrent course of each inferior laryngeal nerve, see p. 909.

Cervical Cardiac Branches.—These are subject to variation as regards numbers. As a rule, there are two, upper and lower, both of which contain bulbar fibres from the spinal accessory. Those of the right side pass behind the first part of the subclavian artery, and end in the *deep* cardiac plexus. On the left side the **upper** nerve passes to the *deep* cardiac plexus, but the **lower** nerve terminates in the *superficial* cardiac plexus.

Summary of the Pneumogastric Nerve in the Neck—1. **Motor Distribution.**—The nerve supplies (1) the muscles of the soft palate, except the tensor palati; (2) the constrictor muscles of the pharynx; (3) the intrinsic muscles of the larynx; and (4) the muscular tissue of the œsophagus and trachea. 2. **Sensory Distribution.**—It supplies (1) the pharynx, œsophagus, and trachea; (2) a limited portion of the dura mater; and (3) a small portion of the skin on the inner surface of the auricle, as well as of the lower and back part of the external auditory meatus. 3. **Communications.**—Each pneumogastric nerve forms connections with the facial, glosso-pharyngeal, spinal accessory, hypoglossal, and sympathetic nerves. It is also connected with the loop between the first and second cervical spinal nerves. Its most important connection is that which is established with the bulbar or accessory portion of the spinal accessory nerve. The bulbar fibres of the nerve are probably chiefly concerned in the innervation of the muscles of the soft palate (except the tensor palati), pharynx, and larynx, but also to a certain extent in the innervation of the heart.

Spinal Accessory Nerve.

The spinal accessory or eleventh cranial nerve consists of two parts, bulbar or accessory, and spinal. In the jugular foramen these two parts either unite to form one trunk, or freely intermingle, and a communication is established between the accessory part and the ganglion of the root of the pneumogastric by means of two twigs. The nerve emerges through the jugular foramen, being enclosed in the same sheath of dura mater as the pneumogastric, behind which it lies. Immediately beneath the jugular foramen the two parts of the nerve separate from each other.

The **bulbar** or **accessory part** passes over, but in intimate contact with, the ganglion of the trunk of the pneumogastric, and its fibres are continued partly into the pharyngeal and superior laryngeal branches of the ganglion of the trunk, and partly into the trunk of the vagus below the ganglion. These latter fibres are ultimately prolonged into the cardiac and recurrent laryngeal branches of the nerve. The bulbar or accessory fibres of the spinal accessory are regarded as (1) the motor nerves of (*a*) the muscles of the soft

palate, except the tensor palati, (*b*) the constrictor muscles of the pharynx, and (*c*) the intrinsic muscles of the larynx; and (2) the inhibitory fibres of the heart.

The **spinal part** of the spinal accessory nerve passes backwards and downwards either behind or in front of the internal jugular

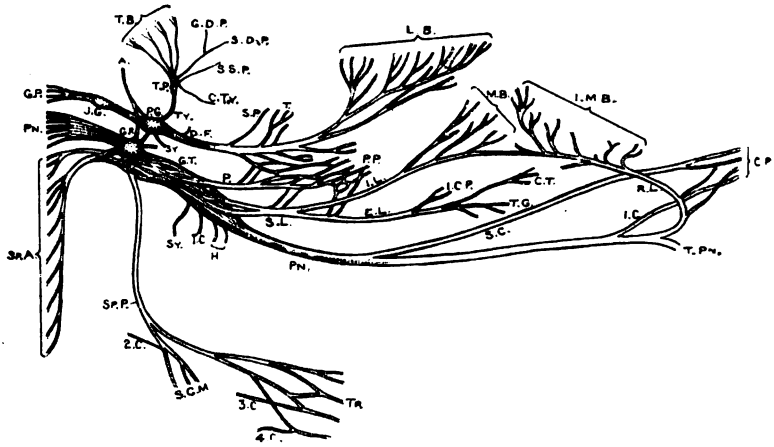


FIG. 484.—SCHEME OF THE GLOSSO-PHARYNGEAL, PNEUMOGASTRIC, AND SPINAL ACCESSORY NERVES (FLOWER).

G.P. Glosso-Pharyngeal.

J.G. Jugular Ganglion
P.G. Petrous Ganglion
Tv. Tympanic Branch (Jacobson's Nerve)
C.Tv. Carotico-tympanic Nerve
T.P. Tympanic Plexus
T.B. Branches to Tympanum
S.S.P. Small Superficial Petrosal
S.D.P. Small Deep Petrosal
G.D.P. Branch to Great Deep Petrosal
Sy. Communicating from Sympathetic
D.F. Twig from Digastric Branch of Facial
S.P. Branch to Stylo-pharyngeus Muscle
T. Tonsillar Branches
L.B. Lingual Branches

PN. Pneumogastric.

G.R. Ganglion of Root
A. Auricular Branch (Arnold's Nerve)
G.T. Ganglion of Trunk
Sy. Communicating from Sympathetic
1c. Branch from First Cervical
H. Communicating with Hypoglossal
P. Pharyngeal Branch
P.P. Pharyngeal Plexus
S.L. Superior Laryngeal
I.L. Internal Laryngeal
M.B. Branches to Mucous Membrane of Larynx
E.L. External Laryngeal
I.C.P. Branch to Inferior Constrictor Muscle
T.G. Branches to Thyroid Body
C.T. Branch to Crico-thyroid Muscle
S.C. Superior Cardiac Branch
I.C. Inferior Cardiac Branch
R.L. Recurrent Laryngeal
I.M.B. Branches to Intrinsic Laryngeal Muscles (except Crico-thyroid)
C.P. To Cardiac Plexus
T.PN. Thoracic Pneumogastric

SP.A. Spinal Accessory.

SP.P. Spinal Portion of Spinal Accessory
2c. From Second Cervical
S.C.M. To Sterno-cleido-mastoid
3c. From Third Cervical
4c. From Fourth Cervical
TR. To Trapezius

vein. It then pierces the deep surface of the sterno-cleido-mastoid, which it supplies along with a branch of the second cervical nerve. Thereafter it crosses the posterior triangle of the neck obliquely downwards and backwards to the anterior border of the trapezius, beneath which it passes, supplying the muscle, in company with branches from the third and fourth cervical nerves.

Summary.—The **spinal portion** of the spinal accessory nerve supplies two muscles, namely, the trapezius and the sterno-cleido-mastoid. The **bulbar portion,** through its connection with the pneumogastric nerve and its branches, supplies (1) the muscles of the soft palate, except the tensor palati; (2) the constrictor muscles of the pharynx; and (3) the intrinsic muscles of the larynx. It also furnishes the *inhibitory fibres* of the heart, which reach that organ through the cardiac branches of the pneumogastric.

Hypoglossal Nerve.

The hypoglossal or twelfth cranial nerve consists at first of two bundles, which pierce the dura mater separately. In passing through the anterior condylar foramen these two bundles unite to form one trunk. After emerging from that foramen the nerve lies deeply under cover of the internal carotid artery and internal jugular vein. It then turns round the outer side of the ganglion of the trunk of the pneumogastric, with which it is closely connected, and passes forwards between the internal carotid artery and internal jugular vein. Thereafter it descends to the lower border of the posterior belly of the digastric, at which level it hooks round the occipital artery from without inwards, and crosses in front of the external carotid artery and its lingual branch. In this part of its course the nerve lies in the superior carotid triangle. It next courses forwards above the hyoid bone, passing beneath the tendon of the digastric and the lower part of the stylo-hyoid muscle, and resting on the hyo-glossus. Thereafter it disappears beneath the mylo-hyoid, still resting upon the hyo-glossus, where it is accompanied by the ranine vein, and lies below the deep part of the submaxillary gland. At the anterior border of the hyo-glossus it is connected with the lingual nerve, and then enters the genio-hyo-glossus.

Branches—1. **Of Communication.**—After emerging from the anterior condylar foramen, the hypoglossal nerve communicates with the ganglion of the trunk of the pneumogastric. It then receives a branch from the superior cervical ganglion of the sympathetic, and one from the first cervical nerve, or the loop between the first and second. As it hooks round the occipital artery, it receives the lingual branch of the vagus from the pharyngeal plexus; and at the anterior border of the hyo-glossus it is connected with the lingual nerve.

2. **Of Distribution.**—One or two *meningeal branches* arise from the nerve in the anterior condylar foramen, which take a recurrent course, and enter the cranial cavity to supply the dura mater in the vicinity of the foramen.

The *descendens cervicis* (descendens hypoglossi) nerve has been already described (see p. 1032).

The *thyro-hyoid nerve* will be found described on p. 1033.

The *muscular branches* are given off from the nerve as it lies upon the hyo-glossus under cover of the mylo-hyoid. These supply the stylo-glossus, hyo-glossus, genio-hyo-glossus, and genio-hyoid. The

nerve to the genio-hyoid is generally regarded as being composed of spinal fibres, derived from the first, second, and third cervical nerves.

The *terminal* or *glossal branches* pierce the under surface of the tongue, and are distributed to its muscular tissue.

The hypoglossal nerve receives many spinal fibres. Those derived from the first cervical nerve, or the loop between the first and second, soon become applied to it, and the most of them pass off to form the descendens cervicis nerve. A few of these, however, still pass along the main trunk. The spinal fibres derived from the second and third cervical nerves in part ascend in the descendens cervicis nerve, and then pass off from it to be applied to the main trunk in its onward course.

Summary—1. **Distribution.**—The hypoglossal fibres of the nerve supply the stylo-glossus, hyo-glossus, genio-hyo-glossus, and intrinsic muscles of the tongue. The spinal fibres supply both bellies of the omo-hyoid, the sterno-hyoid, sterno-thyroid, thyro-hyoid, and genio-hyoid muscles. The hypoglossal nerve also supplies the dura mater in the vicinity of the cranial aspect of the anterior condylar foramen. 2. **Connections.**—It establishes connections with (1) the ganglion of the trunk of the vagus; (2) the superior cervical ganglion of the sympathetic; (3) the first, second, and third cervical nerves; (4) the pharyngeal plexus, through means of the lingual branch of the vagus; and (5) the lingual nerve from the inferior maxillary division of the fifth cranial nerve.

Gangliated Cord of the Sympathetic.

Cervical Portion.—This portion of the sympathetic cord extends from the base of the skull, at the foramen caroticum on the under surface of the petrous part of the temporal bone, to the root of the neck, where it enters the thorax, passing, on the right side, behind the subclavian artery. It lies directly behind the carotid sheath, and in front of the transverse processes of the cervical vertebræ, resting upon the rectus capitis anticus major and longus colli muscles. The cord presents three ganglia—superior, middle, and inferior.

Superior Cervical Ganglion.—This ganglion is elongated and fusiform. It is regarded as representing four ganglia united into one, and corresponding to the first four cervical nerves. It is situated in front of the transverse processes of the second and third cervical vertebræ, and lies upon the rectus capitis anticus major, the pneumogastric nerve being external to it. At either end it tapers, being continued superiorly into its ascending branch, and inferiorly into the descending cord.

Branches.—These are numerous and complicated. They may be conveniently arranged into ascending, external or communicating, internal or pharyngeal, superior cardiac, and anterior or vascular.

The **ascending branch** enters the carotid canal in the petrous part of the temporal bone, in company with the internal carotid artery.

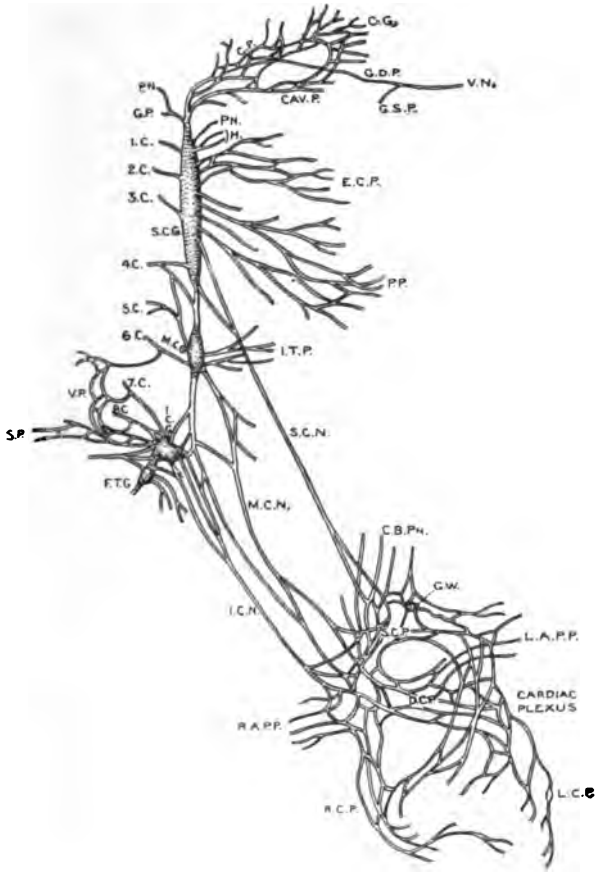


FIG. 485.—SCHEME OF THE SYMPATHETIC NERVE IN THE NECK, AND OF THE CARDIAC PLEXUS (FLOWER).

S.C.G. Superior Cervical Ganglion.

P.N. and G.P. Branches to Pneumogastric and Glosso-pharyngeal
1c, 2c, 3c, 4c. Branches to Upper Four Cervical Nerves
C.P. Carotid Plexus
Cav. P. Cavernous Plexus
C.G. Branch to Ciliary Ganglion
G.D.P. Great Deep Petrosal
G.S.P. Great Superficial Petrosal
V.N. Vidian Nerve
P.N. To Ganglion of Trunk of Pneumogastric
H. To Hypoglossal
E.C.P. To External Carotid Plexus
P.P. To Pharyngeal Plexus
S.C.N. Superior Cardiac Nerve

M.C.G. Middle Cervical Ganglion.

5c, 5c. To Fifth and Sixth Cervical Nerves
I.T.P. To Inferior Thyroid Plexus
M.C.N. Middle Cardiac Nerve

I.C.G. Inferior Cervical Ganglion.

7c, 8c. To Seventh and Eighth Cervical Nerves
V.P. To Vertebral Plexus
S.P. To Subclavian Plexus
I.C.N. Inferior Cardiac Nerve

F.T.G. First Thoracic Ganglion

Cardiac Plexus.

C.B.PN. Cardiac Branches of Pneumogastric
S.C.P. Superficial Cardiac Plexus
G.W. Ganglion of Wrisberg
D.C.P. Deep Cardiac Plexus
R.A.P.P. Right Anterior Pulmonary Plexus
L.A.P.P. Left Anterior Pulmonary Plexus
R.C.P. Right Coronary Plexus
L.C.P. Left Coronary Plexus

and divides into two parts. The *external division* lies upon the outer side of the artery, and its subdivisions form by their interlacement the **carotid plexus.** From this plexus several communicating branches are given off. (1) The carotico-tympanic nerve enters the tympanum, and joins the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal, to take part in the tympanic plexus. (2) The great deep petrosal nerve joins the great superficial petrosal from the geniculate ganglion of the facial, in the upper part of the foramen lacerum medium, to form the Vidian nerve, which passes through the Vidian canal to join Meckel's ganglion. (3) A branch (or branches) passes to join the sixth cranial nerve. (4) One or more branches pass to join the Gasserian ganglion. The carotid plexus furnishes filaments to the coats of the internal carotid artery, and it receives the small deep petrosal nerve from the tympanic plexus.

The *internal division* of the ascending branch of the superior cervical ganglion lies upon the inner side of the internal carotid artery, to which it furnishes twigs, and its subdivisions form by their interlacement the **cavernous plexus.** This plexus lies in contact with the internal carotid artery as it traverses the cavernous sinus. Its communicating branches pass to join the third, fourth, and ophthalmic division of the fifth cranial nerves, and the ciliary or lenticular ganglion. The last-named branch forms the sympathetic root of the ciliary ganglion, and enters the orbit through the sphenoidal fissure. It is the source of the motor supply of the dilator pupillæ muscle. The cavernous plexus furnishes filaments to the coats of the internal carotid artery, and offsets which accompany the branches of that artery, around which they are disposed as plexuses.

The **external branches** are communicating, and pass to (1) each of the upper four cervical nerves ; (2) the petrosal ganglion of the glosso-pharyngeal ; (3) the ganglion of the root, and the ganglion of the trunk, of the vagus ; and (4) the hypoglossal nerve.

The **internal branches** are pharyngeal and cardiac. The **pharyngeal branches,** two or three in number, unite with the pharyngeal branches of the glosso-pharyngeal and vagus to form the pharyngeal plexus (see p. 1149).

The **superior cardiac nerve** arises by two roots from the lower part of the superior cervical ganglion, and descends behind the carotid sheath, lying internal to the main sympathetic cord. The nerve of the right side passes either over or beneath the first part of the subclavian artery, and then along the innominate artery, to terminate in the *deep* cardiac plexus. In its course down the neck it receives twigs from the external laryngeal nerve, and is joined by the upper cervical cardiac branch of the pneumogastric nerve. As it enters the thorax, it receives a filament from the recurrent laryngeal nerve. The nerve of the left side within the thorax accompanies the left common carotid artery, and passes over the arch of the aorta to terminate in the *superficial* cardiac plexus.

The **anterior branches** are vascular, and pass to the external carotid artery, upon which and its branches they form delicate plexuses.

Middle Cervical Ganglion.—This ganglion is situated opposite the sixth cervical vertebra, and usually lies close to the inferior thyroid artery. It is the smallest of the three, and probably represents two ganglia united into one. Occasionally it is absent. It is connected by grey rami with the fifth and sixth cervical nerves, and its branches of distribution are thyroid and middle cardiac. The **thyroid branches** accompany the inferior thyroid artery to the thyroid body, and they communicate with the external and recurrent laryngeal nerves. The **middle cardiac nerve** of each side terminates in the *deep* cardiac plexus. The nerve of the right side passes either in front of, or behind, the first part of the right subclavian artery. It then descends in front of the trachea, and joins the right half of the deep cardiac plexus. The nerve of the left side enters the thorax between the left common carotid and left subclavian arteries, and it joins the left half of the deep cardiac plexus.

Inferior Cervical Ganglion.—This ganglion is situated between the transverse process of the seventh cervical vertebra and the neck of the first rib, where it lies behind the root of the vertebral artery. It is intermediate in size between the superior and middle ganglia, and, like the middle, it probably represents two ganglia united into one. It is frequently fused with the first thoracic ganglion. One or two cords establish a communication between it and the middle cervical ganglion, passing in front of the first part of the subclavian artery. The cord or cords in front of the vessel form a loop around it, called the **ansa Vieussenii,** or *ansa subclavia*. The inferior cervical ganglion is connected by grey rami with the seventh and eighth cervical nerves, and its branches of distribution are vascular and inferior cardiac. The **vascular branches** accompany the vertebral artery in the form of the *vertebral plexus*, which gives filaments to the vessel and offshoots along its various branches. The plexus is continued along the basilar artery and its branches, and on to the posterior cerebral arteries. The **inferior cardiac nerve** on each side joins the *deep* cardiac plexus. The nerve of the right side passes behind the first part of the right subclavian artery, and then in front of the trachea. It is connected with the middle cardiac and recurrent laryngeal nerves. The nerve of the left side in many cases joins the middle cardiac nerve, and so reaches the deep cardiac plexus.

Constitution of the Cervical Sympathetic Cord.

The sympathetic cord in the neck contains the following important groups of fibres, namely, (1) dilator pupillæ, (2) vaso-constrictor and vaso-dilator, (3) secretory, and (4) accelerator.

The **dilator pupillæ fibres** are derived from the *upper three thoracic nerves*, and ascend in the sympathetic cord to the superior cervical ganglion, in which they terminate. From this ganglion they are continued as sympathetic

fibres to the cavernous plexus, through this plexus to the ciliary ganglion, and thence to the dilator pupillæ muscle.

The **vaso-constrictor fibres** are derived from a variable number of thoracic nerves, commencing at the second and terminating at the eighth. The origin of the **vaso-dilator fibres** is not definitely known. The vaso-constrictor fibres ascend to the superior cervical ganglion, in which they terminate. From this ganglion they are continued as sympathetic fibres into the plexus around the external carotid artery, and thence along the branches of that vessel.

The **secretory fibres** are destined for the submaxillary gland, and are derived chiefly from the second and third thoracic nerves. They also ascend to the superior cervical ganglion, in which they terminate. They are thence continued as sympathetic fibres into the external carotid plexus, from that into the facial plexus, and thence into the submaxillary ganglion, from which they pass into the submaxillary gland.

The **accelerator fibres of the heart** are chiefly derived from the second and third thoracic nerves, but some also spring from the first, fourth, and fifth nerves. The spinal fibres pass to the middle and lower cervical ganglia, from each of which they are continued as sympathetic fibres.

The Mouth.

The mouth, or buccal cavity, extends from the *rima oris* in front, where it opens externally on the face, to the isthmus faucium behind, where it opens into the pharynx. It is divided by the upper and lower dental arches into two compartments, the anterior of which is called the vestibule and the posterior the mouth proper.

The **vestibule** is bounded anteriorly and externally by the lips and cheeks, and internally by the dental arches and gums. Superiorly and inferiorly it is bounded by the reflection of the mucous membrane from the lips and cheeks on to the gums. In the median line, above and below, the mucous membrane forms a small vertical fold, called the *frenulum labii*. On the inner surface of each cheek the vestibular mucous membrane presents a small papilla opposite the second upper molar tooth, and on this is the minute opening of Stensen's duct.

The **mouth proper** lies within the dental arches. It communicates with the vestibule by the interval between the upper and lower teeth, and also by an opening at either side situated behind the last molar tooth. Anteriorly and externally it is bounded by the dental arches and gums, and posteriorly it opens into the pharynx by means of the isthmus faucium. The *roof*, which is arched, is formed by the hard palate and the velum pendulum palati, or soft palate. The *floor* is formed by the tongue, and the reflection of mucous membrane from the inner surface of the lower dental arch on to its under surface. In the region of the tip of the tongue the lateral reflections of mucous membrane from the two sides of the lower dental arch are continuous across the median line. In the median line the mucous membrane forms a prominent fold, called the *frenum linguæ*, which is connected above with the under surface of the tongue a little distance from the tip. In some children it may extend quite to the tip, impairing the utility of the organ, and giving rise to the condition known as 'tongue-tied.' Close to

each side of the frenum there is a small papilla, on which is the opening of Wharton's duct, and near to this is the opening of the duct of Rivini or of Bartholin, which comes from the outermost lobule of the sublingual gland. A little posterior to this is a fold of the mucous membrane, at either side, produced by the upper border of the subjacent sublingual gland. This fold is known as the *plica sublingualis*, and it extends from the side of the tongue to the dental arch. It is upon this plica that the majority of the ducts of Walther (sublingual ducts) open.

The **lips** are covered by skin externally, and mucous membrane internally. Between these two layers are the muscular fibres

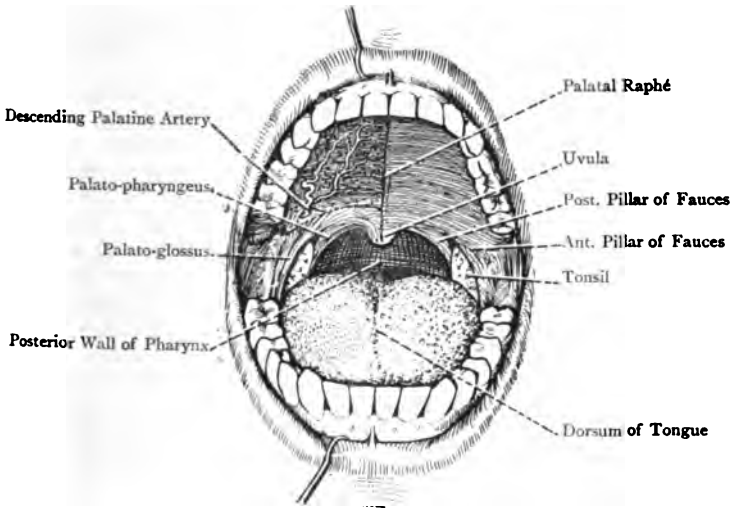


FIG. 486.—THE BUCCAL CAVITY AND ISTHMUS FAUCIUM.
The Maxillæ are widely separated.

of the orbicularis oris, blended with which are the fibres of the buccinator, and, in the case of the upper lip, fibres of the depressor anguli oris, whilst in the case of the lower lip there are the fibres of the levator anguli oris. Between the mucous membrane and the muscular element there are a number of small racemose glands, called the labial glands, the ducts of which open on the inner surface of each lip. The tortuous coronary arteries are embedded in each lip, and those of opposite sides anastomose at the median line.

The **cheeks** are covered externally by skin, and internally are lined with mucous membrane. The muscular element consists of the buccinator, which is covered by the buccal fascia. Posteriorly this fascia is continuous with the pharyngeal fascia, which is derived from the deep cervical fascia, the two being known as the

bucco-pharyngeal fascia. Superiorly and inferiorly it is attached to the dental arches.

The **buccal pad of fat** is situated upon the buccal fascia, and is well developed in young children. It is of soft consistence, and is continuous with the fat beneath the temporal muscle under cover of the ramus of the lower jaw.

The buccal fascia, buccinator, and lining mucous membrane are pierced by Stensen's duct. Between the buccinator and the mucous membrane there are several racemose buccal glands. In addition to these there are three or four molar glands, mucous in character, which are situated superficial to the buccal fascia in the angle between the masseter and buccinator.

The **masseteric fascia** is an upward prolongation of the deep cervical fascia. It is attached superiorly to the zygoma, and externally is continuous with the parotid fascia.

The **dental arches** are formed by the alveolar borders of the superior and inferior maxillæ, the teeth, and the gums.

The **mucous membrane of the gums** is separated from the subjacent periosteum by dense connective tissue, which connects the two in such a close manner that the mucous membrane is immovable. Close to the necks of the teeth it is beset with papillæ. The **mucous membrane of the hard palate,** like that of the gums, is separated from the periosteum by a thick layer of dense connective tissue, which binds the two so closely that the mucous membrane is immovable. It presents a median raphé, which is continued over the soft palate, and ends in front at the anterior palatine fossa in a small papillary elevation, known as the *incisor papilla.* On either side of the raphé anteriorly there are a few transverse rugæ. Each lateral half of the hard palate is traversed by the ramifications of the descending palatine artery, the branches of which extend forwards and inwards from either lateral angle posteriorly. The mucous membrane of the hard palate is provided with racemose palatal glands of a serous character, which are arranged in two symmetrical groups laterally disposed.

Nerves.—The **great** or **anterior palatine nerve** descends in the posterior palatine canal, from which it emerges through the posterior palatine foramen. Thereafter it divides into branches which pass forwards in grooves on the hard palate, and supply the mucous membrane, glands, and inner aspect of the upper gum. The **naso-palatine nerve** is distributed to the mucous membrane behind the incisor teeth, where it communicates with twigs of the great or anterior palatine nerve. To reach the hard palate the nerve of the right side passes through the *posterior foramen* of Scarpa, whilst the left nerve passes through the *anterior* foramen. The mucous membrane of the cheek is supplied by the long buccal nerve, which is a branch of the inferior maxillary division of the fifth cranial nerve. The mucous membrane of the floor of the mouth derives its nerves from the submaxillary ganglion.

Arteries.—These are the right and left descending palatine

branches of the third part of the internal maxillary. Each descending palatine artery takes the same course as, and has a similar distribution to, the great or anterior palatine nerve. At the anterior palatine fossa it terminates in a small branch which ascends through Stensen's canal, and anastomoses at the upper end of that canal with the naso-palatine branch of the spheno-palatine artery.

Development of the Mouth and Nasal Cavities.—The **stomatodæum** (**stomodæum**), or primitive mouth, makes its appearance as a depression of the epiblast on the ventral wall of the fore-gut between the fore-brain and the pericardial region. This epiblast comes into contact with the hypoblast of the fore-gut, and the bilaminar structure so formed is known as the **buccopharyngeal septum,** or **oral plate.** When this septum ruptures the stomatodæum is formed, and the fore-gut now opens externally. At a later period the stomatodæum becomes bounded on either side by the first or mandibular arch, and above by the fronto-nasal process. Subsequently the two mandibular arches, coming together, fuse, and form the lower boundary of the stomatodæum. Thereafter the formation of the lower and upper dental arches, the roof of the mouth, and the nasal cavities takes place.

From the stomatodæum are developed the epithelium of the vestibular portion of the mouth, gums, salivary glands, and the greater part of that of the nasal cavities, as well as the anterior lobe of the pituitary body.

Each half of the inferior maxilla or mandible, as stated in the section of Osteology (p. 151), is formed chiefly from the fibrous tissue which surrounds a portion of Meckel's cartilage, this being the bar of cartilage which forms the skeletal framework of the mandibular arch ; but the symphysial part of the mandible is developed from the mesial end of Meckel's cartilage.

The mandibular process of each mandibular arch grows forwards between the eye and the mouth, and it gives rise to the chief part of the superior maxilla, including the greater portion of one half of the hard palate. The part of the hard palate which is formed by the palate bone is developed from the pterygo-palatine bar of cartilage within the maxillary process. The premaxillary part of the hard palate on either side is developed from the globular process, which belongs to the mesial nasal process of the fronto-nasal process.

By the formation of the hard palate on either side, the stomatodæum becomes divided into two compartments, namely, a lower, which represents the permanent mouth, and an upper, which represents the nasal cavity, at this period single. This single cavity becomes subsequently divided into the two nasal chambers by the growth of the nasal septum (see pp. 150 and 151).

For the formation of the lateral wall of each nasal chamber, see p. 151.

For some time a wide communication exists between the mouth and nasal chambers anteriorly. It is situated between the parts of the hard palate which are developed from the maxillary and globular processes. This, however, becomes gradually diminished as the hard palate becomes completed, and eventually it is represented in man on either side by the incisor canal, or canal of Stensen. In certain animals, *e.g.*, ruminantia, a wide communication persists on either side between the anterior part of the hard palate and each nasal chamber, which leads to the organ of Jacobson.

The **olfactory organ** is developed from the **olfactory pits,** which appear as two depressions of the epiblast in the region of the fronto-nasal process. These olfactory pits divide the fronto-nasal process into mesial and lateral nasal processes, and they extend backwards into the roof of the stomatodæum. Each pit is lined with epiblast, which gives rise to the olfactory epithelium, and, in part, to the olfactory bulb.

The Tongue.

The tongue is a muscular and very sensitive organ, covered by the buccal mucous membrane, and situated on the floor of the mouth. It is concerned in the sense of taste, mastication, deglutition, and speech, and it consists of a root or base, a body, and a tip. The root is attached by muscles to the hyoid bone. The tip is the anterior free extremity, which, in the quiescent state, lies behind the upper incisor teeth. The body presents an upper surface or dorsum, an under surface, and two lateral borders, right and left. The dorsum is convex from before backwards, and presents over its anterior two-thirds a median depression or raphé, on either side of which the surface is convex from side to side. This raphé terminates posteriorly in the foramen cæcum. In this region the dorsum presents a V-shaped groove, known as the *sulcus terminalis*. The point of the V is at the foramen cæcum, and the two limbs pass outwards and forwards to the sides of the tongue, where the anterior pillars of the fauces are connected with it. The sulcus terminalis marks the union of the two portions, anterior and posterior, from which the tongue is developed. The portion behind it, representing one-third, is the basal, lymphoid, or **pharyngeal portion.** It occupies the buccal portion of the pharynx, and overhangs the epiglottis. The portion in front of the sulcus terminalis, representing two-thirds, is known as the **buccal** or **papillary portion.**

Mucous Membrane.—The mucous membrane covering the basal or pharyngeal portion of the tongue is destitute of proper papillæ, but is freely provided with lymphoid follicles similar to those of the tonsils, and with mucous glands. The follicles are ranged upon the walls of crypts, the mouths of which open upon the surface. The mucous membrane in this region forms the **glosso-epiglottidean fold,** or **frenum epiglottidis,** which is mesially placed. On either side of this fold, between it and each pharyngo-epiglottidean fold, there is a pouch or depression, called the **vallecula.** In front of the sulcus terminalis the mucous membrane of the dorsum, borders, and tip of the tongue is freely covered by characteristic papillæ, which, being visible to the naked eye, impart to this part its distinctive appearance. These papillæ bear secondary papillæ, which, however, are concealed by the epithelial covering. The mucous membrane on the under surface of the tongue in the median line forms, near the tip, a vertical fold, called the *frenum linguæ*. A little external to the frenum, on either side, is an indistinct fringed fold, called the *plica fimbriata*. The two plicæ converge as they pass forwards towards the tip, and inside each the outline of the ranine vein may be visible. On either side of the tongue, in the region of the limbs of the sulcus terminalis, the mucous membrane presents a few ridges which represent the papillæ foliatæ of such animals as the rabbit.

Papillæ.—These are of three kinds, namely, conical, fungiform, and circumvallate, and they are confined to the anterior two-thirds of the organ. The **conical papillæ** are the most numerous, and are arranged in more or less parallel, closely-set rows, directed forwards and outwards from the median line, except towards the tip, where the rows tend to become transverse. On the sides of the tongue they are arranged in vertical parallel rows. In some

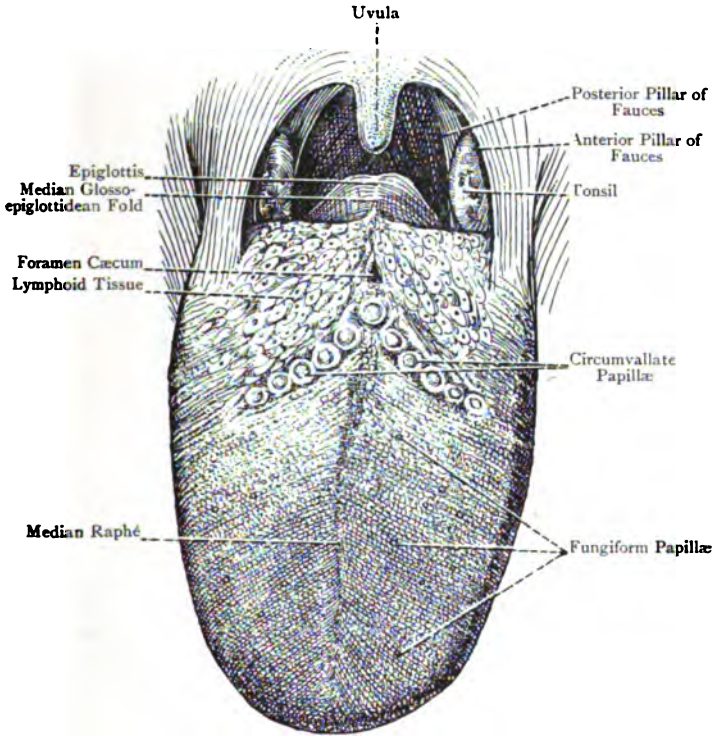


FIG. 487.—THE DORSUM OF THE TONGUE, AND THE FAUCES.

conical papillæ the epithelium which caps the secondary papillæ forms thread-like processes. Such are known as **filiform papillæ.**

The **fungiform papillæ** are scattered amongst the conical, and are most numerous at the sides and tip, being rather sparse over the dorsum. Each is round and enlarged at the surface, but tapers at its deep end, and it bears secondary papillæ, but there is no filiform arrangement of the epithelial caps.

The **circumvallate papillæ** are conspicuous, and vary in number from seven to thirteen. They are arranged in two diverging rows,

which lie anterior to, and parallel with, the limbs of the sulcus terminalis. The two rows converge backwards and inwards, and so form a capital **V**. In the median line, at the point of the **V**, there is a single circumvallate papilla, behind which is the foramen cæcum. The free surface of each papilla is broad and flat, and bears secondary papillæ, whilst the deep end is somewhat constricted, and is received into a circular pit of the mucosa. In this manner each papilla is surrounded by a space known as the trench. The outer wall of the trench projects slightly beyond the level of the free surface of the papilla, thus forming a circular elevation around it, called the *vallum* (rampart). It is from this circumstance that the papillæ

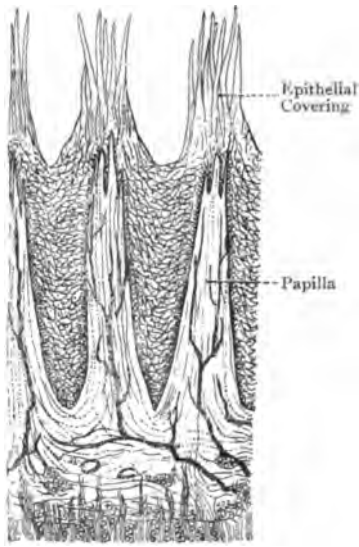


FIG. 488.—THE CONICAL (FILIFORM) PAPILLÆ OF THE TONGUE.

have received the name 'circumvallate.' Their sides, as well as the wall of the vallum, contain the taste-buds.

The tongue contains a number of acinous glands. Some of them open into the trenches around the circumvallate papillæ, where taste-buds are present, and are serous in character, these being known as the **glands of Ebner.** Others open into the foramen cæcum, into the crypts on the posterior third of the dorsum, and along the sides of the organ, these being mucous in character, and being known as the **glands of Weber.** Beneath the apex of the tongue, on either side of the median line, there is a small group of glands, partly serous and partly mucous. These two groups are known as the **glands of Blandin,** or of **Nuhn.**

The **muscular tissue of the tongue** is of the striped variety. It forms two sets of muscles, namely, extrinsic and intrinsic. The *extrinsic muscles* are those which have their origins outside the tongue, and their insertions into it. They are as follows : (1) the genio-hyo-glossus, (2) the hyo-glossus (including the chondro-glossus), (3) the stylo-glossus, and (4) the palato-glossus, all of which have been already described. The *intrinsic muscles* are those which are contained entirely within the tongue, and they are arranged in pairs on either side of the median fibrous septum,

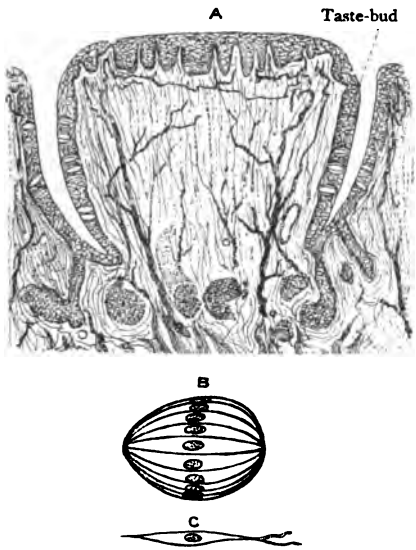


FIG. 489.—VERTICAL SECTION OF A CIRCUMVALLATE PAPILLA OF THE TONGUE.

A, Circumvallate Papilla, beset with Secondary Papillæ ;
B, Taste-bud ; C, Gustatory Cell.

which extends from the tip of the tongue as far back as the body of the hyoid bone. The intrinsic muscles are as follows : (1) the lingualis superficialis, (2) the lingualis inferior, (3) the lingualis transversus, and (4) the lingualis verticalis.

The **lingualis superficialis** is an expanded sheet placed on the dorsum, immediately beneath the mucous membrane. Its fibres are disposed longitudinally, and the muscle extends from the tip backwards to the body of the hyoid bone. Posteriorly it is overlapped by fibres of the hyo-glossus. Its fibres do not extend over the whole length of the tongue, but take attachment, at short intervals, to the mucous membrane.

The **lingualis inferior** is disposed as a round bundle on the inferior surface of the tongue. Posteriorly it lies between the insertions of the genio-hyo-glossus internally and the hyo-glossus externally, and anteriorly, between the former muscle internally and the stylo-glossus externally. The muscle extends from the tip of the tongue to the body of the hyoid bone, with which it is connected.

The **lingualis transversus** constitutes a layer of considerable thickness, which is placed between the lingualis superficialis and

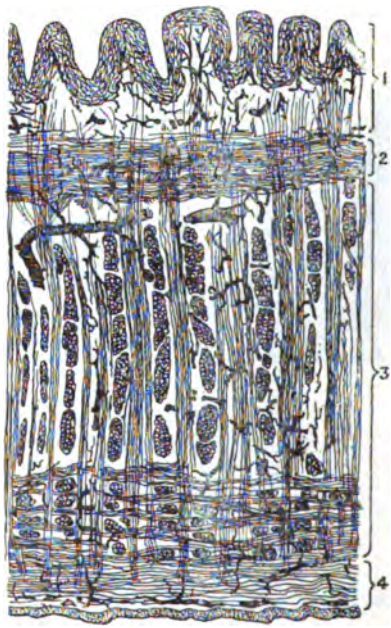


FIG. 490.—LONGITUDINAL SECTION OF THE TONGUE OF A CAT (INJECTED).

1. Mucosa
2. Lingualis Superficialis
3. Lingualis Transversus et Verticalis
4. Lingualis Inferior

lingualis inferior. It arises from the median septum, and extends outwards, the upper fibres curving upwards, to be inserted into the mucous membrane of the side of the tongue and adjacent portion of the dorsum. This muscular stratum is interspersed with fat, and is much broken up by fibres of the lingualis verticalis and genio-hyo-glossus.

The **lingualis verticalis** extends from the mucosa of the dorsum to that of the inferior surface. Its fibres describe curves, having the convexities directed inwards, and they decussate freely with the fibres of the lingualis transversus.

Arteries.—These are as follows: (1) the **ranine artery,** which is a branch of the lingual, and is situated on the inferior surface, immediately external to the line of insertion of the genio-hyo-glossus muscle. It anastomoses with its fellow beneath the tip. (2) The **dorsalis linguæ** artery, which is also a branch of the lingual. (3) The **tonsillar branch** of the *cervical portion of the facial* artery. (4) The **palatine branch** of the *ascending pharyngeal* artery.

The **veins** pass to the internal jugular vein.

Lymphatics.—The lymphatics of the anterior part of the tongue pass through the mylo-hyoid muscle to the submaxillary lymphatic glands. Those from the posterior part of the organ pass to the lingual lymphatic glands which are situated on the hyo-glossus muscle, and thence to the upper group of deep cervical glands.

Nerves.—The *sensory nerves* are: (1) the **lingual branch** of the *inferior maxillary division of the fifth cranial* nerve, which is distributed to the mucous membrane over the *anterior two-thirds* of the tongue, including the *conical* and *fungiform papillæ,* upon which it confers common sensibility; (2) the **chorda tympani** nerve, which accompanies the lingual nerve to the anterior two-thirds of the tongue, of which it is usually regarded as the nerve of *special sense;* (3) the **lingual branch** of the *glosso-pharyngeal* nerve, which is distributed to the mucous membrane of the *posterior third* and to the *circumvallate papillæ,* of which it is the nerve of special sense; (4) the **internal branch** of the *superior laryngeal nerve,* which furnishes a few twigs to the mucous membrane of the *root of the tongue,* in the region of the epiglottis; and (5) the **hypoglossal nerve,** which supplies the lingual muscles.

Sympathetic filaments are also conducted to the tongue by the various arteries.

Taste-buds.—These are principally met with on the sides of the circumvallate papillæ, and on the surface of each vallum. They are also present in some fungiform papillæ, over the tongue generally, more especially towards the root, on the buccal surface of the soft palate, and on the epiglottis. They are situated in the thick stratified epithelium. A taste-bud is somewhat ovoid or flask-shaped. The superficial end is narrow, and presents a *gustatory pore,* by which it communicates with the buccal cavity, and through which the distal process of a gustatory cell projects. The base rests upon the mucosa, and gives passage to a nerve-fibre. The wall of the taste-bud is composed of flattened, nucleated epithelial cells, called the **tegmental** or **sustentacular cells,** which are pointed at either end, and cohere by their edges, very much like the staves of a barrel. The interior of the taste-bud contains a bundle of gustatory cells. Each **gustatory cell** contains a nucleus, and is fusiform or spindle-shaped. It is prolonged into two poles. The *distal* or *outer pole* projects through the gustatory pore, at the apex of the bud, in a filiform manner. The *proximal* or *inner pole* is usually branched, and becomes continuous with a nerve-fibre at the base of the bud.

Development.—The *buccal* or *papillary portion* of the tongue (anterior two-thirds) is developed from the **tuberculum impar,** and the *pharyngeal* or *lymphoid portion* (posterior third) is developed from the **ventral ends of the second and third visceral arches on each side.** The **tuberculum impar** makes its appearance as a round eminence in the median line, opposite and between the first visceral clefts. Behind it, and separated from it by a groove, is the **furcula**, which is a forked eminence, mesially placed opposite the second and third visceral arches, and resembling a horseshoe. It gives origin to the

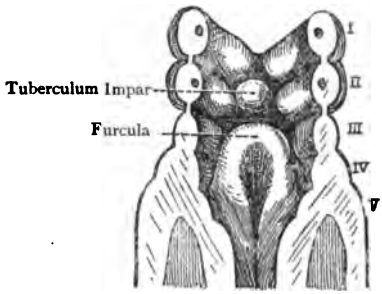


FIG. 491.—THE VISCERAL ARCHES OF THE EMBRYO (POSTERIOR VIEW) (HIS).

I. Mandibular Arch
II. Hyoid Arch
III. Thyro-hyoid Arch
IV. Fourth Arch
V. Fifth Arch

epiglottis and aryteno-epiglottidean folds. The ventral ends of the second and third visceral arches of either side coalesce, and the united ends of these arches join each other in the interval between the tuberculum impar and the furcula. It is from this transverse elevation that the *root* of the tongue is formed. It is developed from it as two elevations, which take an upward and forward direction, diverging at the same time in a V-shaped manner, so as to embrace the part developed from the tuberculum impar. The tuberculum impar, as stated, gives rise to the buccal portion of the tongue. After the pharyngeal and buccal portions of the tongue have coalesced, a V-shaped groove persists for some time, indicating the line of union of the two parts of the organ ; and in adult life this is represented by the *sulcus terminalis.*

The Soft Palate.

The soft palate, or *velum pendulum palati*, is a movable musculo-aponeurotic curtain situated at the back part of the hard palate, where it projects downwards and backwards into the pharynx. Anteriorly it is attached to the posterior border of the hard palate, laterally it is connected with the side of the tongue and the wall of the pharynx, and postero-inferiorly it presents a free border. Its surfaces, which occupy an oblique plane, are antero-inferior or buccal, which is concave, and postero-superior or pharyngeal, which is convex and looks towards the naso-pharynx. The postero-inferior border at its centre presents a conical process, called the **uvula.** On either side of the base of the uvula there are two prominent folds of mucous membrane, which extend outwards and downwards in a diverging manner. These folds constitute the

anterior and **posterior pillars of the fauces.** Each posterior pillar belongs to the postero-inferior border of the soft palate, and it sweeps outwards, downwards, and backwards on the lateral wall of the pharynx. It is due to the palato-pharyngeus muscle. Each anterior pillar belongs to the buccal surface of the soft palate, and it sweeps outwards, downwards, and forwards to the back part of the side of the tongue. It is produced by the palato-glossus muscle. Between the diverging anterior and posterior pillars, on either side, there is a triangular interval, which is occupied by the tonsil. The passage which leads from the buccal cavity into the pharynx is called the **fauces** or **isthmus faucium**. It is somewhat constricted, and is bounded above by the soft palate, below by the

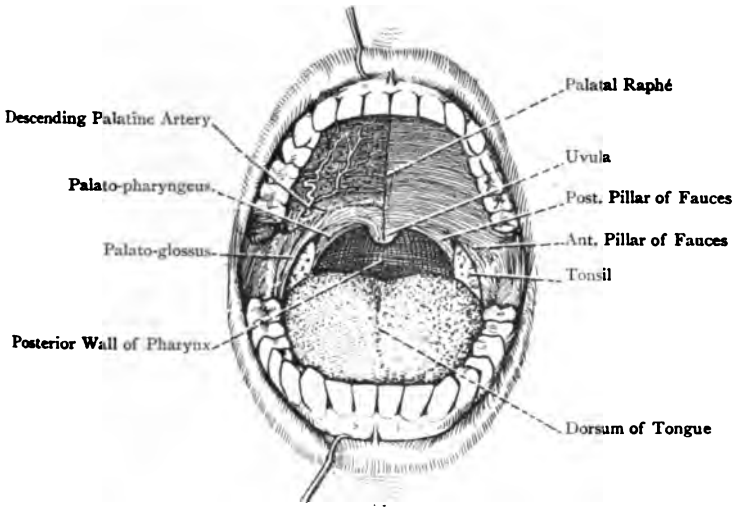


FIG. 492.—THE BUCCAL CAVITY AND ISTHMUS FAUCIUM.
(The Maxillæ are widely separated).

back part of the dorsum of the tongue, and on either side by the anterior pillar of the fauces.

The buccal surface of the soft palate presents a faint mesial raphé.

Structure.—The soft palate is composed of a double fold of mucous membrane, which contains between its two layers an aponeurosis, muscles, and many racemose glands, with bloodvessels and nerves. The **mucous membrane** on the buccal surface presents, as stated, a median raphé, which is continuous with that on the mucous membrane of the hard palate, and along which the originally separate halves of the soft palate unite. On the buccal surface and along the postero-inferior border it is covered by stratified squamous

epithelium, but on the pharyngeal surface by ciliated columnar epithelium. The **glands**, which are racemose or acinous, are especially abundant on the buccal surface beneath the mucous membrane, where they are closely packed together. The **aponeurosis** is attached anteriorly to the posterior border of the hard palate, and laterally it becomes continuous with the aponeurosis of the pharynx. It affords attachment to portions of the palatal muscles.

Muscles.—These are arranged in pairs, and are as follows: palato-glossus, palato-pharyngeus, azygos uvulæ, levator palati, and tensor palati.

Palato-glossus (Constrictor Isthmi Faucium)—*Origin.*—The under surface of the palatal aponeurosis, its fibres being continuous across the middle line with those of the opposite muscle.

Insertion.—The back part of the side of the tongue, where its fibres blend with the transverse muscular fibres of the tongue.

Nerve-supply.—The pharyngeal plexus.

The direction of the muscle is outwards, downwards, and forwards.

Action.—(1) To depress the side of the soft palate, and (2) to draw the tongue upwards and backwards. The two muscles also approximate the anterior pillars of the fauces. By means of these combined actions, aided by the tongue, the isthmus faucium is closed, and the anterior part of the buccal cavity is shut off from the pharynx at the commencement of the second stage of deglutition.

The muscle forms the lowest layer in the soft palate, and it gives rise to the mucous fold, called the anterior pillar of the fauces.

Palato-pharyngeus—*Origin.*—By two layers, upper and lower. The **upper small layer** arises from the aponeurosis of the soft palate above the azygos uvulæ, its fibres decussating with those of the opposite side; and the **lower large layer** arises from the posterior margin of the hard palate, as well as from the palatal aponeurosis, decussating with its fellow of the opposite side.

Insertion.—(1) The superior and posterior borders of the ala of the thyroid cartilage, and (2) the lateral and posterior wall of the pharynx, its fibres blending with those of the stylo-pharyngeus.

The muscle receives an accessory slip from the lower part of the cartilage of the Eustachian tube, which is known as the *salpingo-pharyngeus muscle.*

Nerve-supply.—The pharyngeal plexus.

The muscle is directed downwards and backwards.

Action.—(1) To approximate the posterior pillar of the fauces to its fellow at the commencement of the second act of deglutition, and (2) to elevate the pharynx.

The muscle gives rise to the mucous fold, called the posterior pillar of the fauces.

Azygos Uvulæ—*Origin.*—The side of the posterior nasal spine and the adjacent aponeurosis.

Insertion.—The submucous tissue of the uvula, having previously united with its fellow of the opposite side.

Nerve-supply.—The pharyngeal plexus. The direction of the muscle is backwards and downwards.

Action.—To elevate and shorten the uvula.

The muscle lies above the levator palati, and beneath the upper layer of the palato-pharyngeus.

Levator Palati—*Origin.*—(1) The rough surface on the inferior aspect of the petrous part of the temporal bone between the apex and the carotid foramen, and (2) the lower margin of the cartilage of the Eustachian tube.

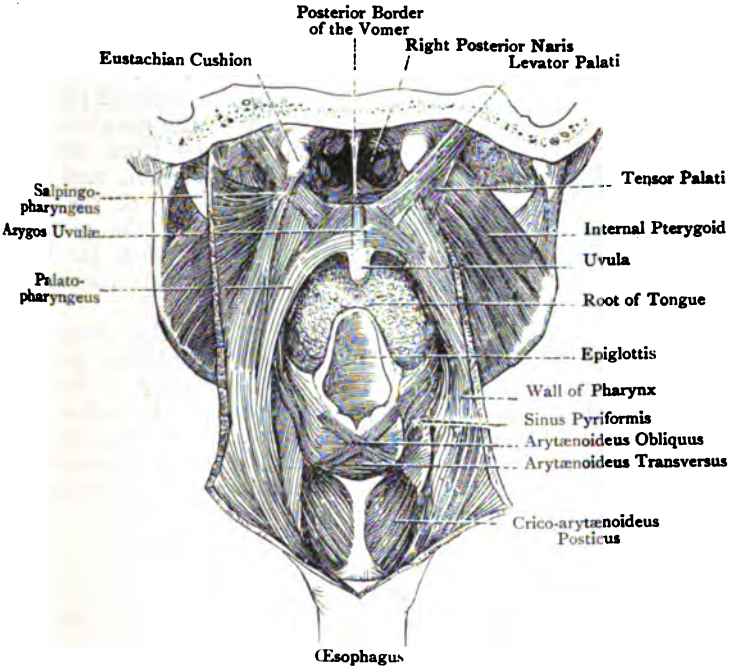


FIG. 493.—THE PHARYNX OPENED FROM BEHIND.

Insertion.—The aponeurosis of the soft palate, its posterior fibres becoming continuous across the middle line with the corresponding fibres of the opposite muscle.

Nerve-supply.—The pharyngeal plexus. Another view, however, is that the muscle is supplied by the posterior descending palatine nerve from Meckel's ganglion, which conveys fibres of the facial nerve through the great superficial petrosal and Vidian nerves.

The muscle is directed downwards, forwards, and inwards.

Action.—(1) To raise the soft palate, and (2) to press upwards the membranous floor of the Eustachian tube, and so lead to closure of the Eustachian orifice during deglutition (Cleland).

The muscle, which is round and fleshy, passes over the upper border of the superior constrictor and through the pharyngeal aponeurosis. At its origin it is closely related to the membranous portion of the Eustachian tube.

Tensor Palati—*Origin.*—(1) The scaphoid fossa at the root of the internal pterygoid plate of the sphenoid; (2) the spine of the sphenoid; and (3) the outer side of the Eustachian tube.

Insertion.—(1) The transverse ridge on the under surface of the horizontal plate of the palate bone, near the posterior border; and (2) the aponeurosis of the soft palate.

Nerve-supply.—A branch from the otic ganglion. Two views are maintained as to the source from which the nerve-fibres are derived. One view is that they come from the inferior maxillary division of the fifth cranial nerve, through the branch to the internal pterygoid muscle, which branch furnishes motor fibres to the ganglion. The other view is that the nerve-fibres are derived from the small superficial petrosal nerve which joins the ganglion, and which represents the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal, reinforced by a small branch from the geniculate ganglion of the facial. According to this latter view the glosso-pharyngeal nerve would be concerned in the innervation of this muscle (Turner).

The muscle at first descends vertically as a flat fleshy band between the internal pterygoid plate and the internal pterygoid muscle, being in close contact with the mesial surface of the latter. As it approaches the hamular process it ends in a tendon, which turns round that process, a synovial bursa intervening, and then passes horizontally inwards, expanding as it does so. From the fact that the muscle is bent around the hamular process it has been called the **circumflexus palati.**

Action.—(1) To make tense the soft palate, and (2) to draw downwards and backwards the margins of the cartilage of the Eustachian tube, and so open the tube during deglutition. (See action of levator palati.) The muscle comes into play during the second stage of deglutition.

Sensory Nerves.—These are (1) the posterior and external palatine nerves from Meckel's ganglion, and (2) the tonsillitic branches of the glosso-pharyngeal.

Arteries.—The soft palate is supplied by the following arteries: (1) the inferior or ascending palatine of the cervical portion of the facial; (2) the palatine branch of the ascending pharyngeal; and (3) the posterior and external branches of the descending palatine artery from the internal maxillary, which descend in the posterior and external accessory palatine canals.

Relation of Structures in the Soft Palate.—Supposing the soft palate to be transfixed from its buccal to its pharyngeal surface, the following structures would be pierced in the order stated: (1) the mucous membrane covering the buccal surface, (2) the layer of closely-set racemose glands, (3) the palato-glossus, (4) the lower

layer of the palato-pharyngeus, (5) the palatal aponeurosis and tensor palati, (6) the levator palati, (7) the azygos uvulæ, (8) the upper layer of the palato-pharyngeus, and (9) the mucous membrane covering the pharyngeal surface.

The Tonsils.

The tonsils (*amygdalæ*) are two in number, right and left. Each is situated in the triangular depression between the anterior and posterior pillars of the fauces on either side, and, above it, is a small recess, known as the **supratonsillar fossa,** which is the remains of the inner portion of the second visceral cleft. The tonsil stands out as an oval enlargement, covered by mucous membrane, and it lies opposite the angle of the inferior maxilla, being under cover of it and

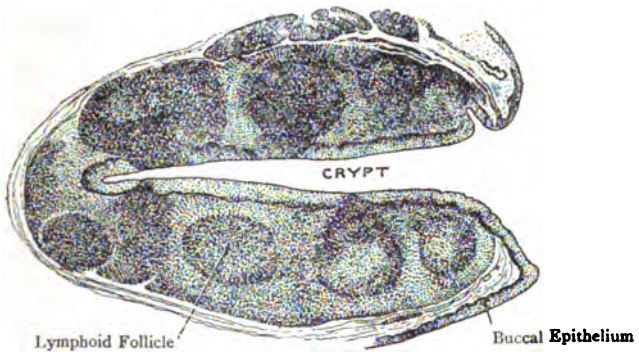


FIG. 494.—SECTION THROUGH A CRYPT OF THE TONSIL.

the adjacent portion of the ramus. The organ varies much in size, but on an average it measures about 1 inch in length, about ¾ inch from before backwards, and about ½ inch from within outwards. The internal surface is pitted with a number of orifices, which lead into crypts in the interior. The outer surface, which has a fibrous covering, is related to the superior constrictor of the pharynx, some loose tissue intervening, and external to the superior constrictor is the internal pterygoid muscle. Two of the tonsillar arteries, namely, the tonsillar and inferior or ascending palatine, lie between the superior constrictor and internal pterygoid. The cervical portion of the facial artery in its course lies a little below the outer aspect of the tonsil. The internal carotid artery is situated about 1 inch from it on its outer and posterior aspect.

Arteries.—These are as follows: (1) the tonsillar and inferior or ascending palatine branches of the cervical portion of the facial; (2) the ascending pharyngeal branches from the external carotid; (3) the dorsalis linguæ from the lingual; and (4) the posterior and

external palatine offsets of the descending palatine artery from the third part of the internal maxillary.

The **veins** form a plexus on the outer surface of the tonsil, from which the blood passes into the pharyngeal plexus.

Lymphatics.—These pass to the upper group of deep cervical glands.

Nerves.—The nerves are derived from (1) the glosso-pharyngeal, (2) the posterior and external palatine branches of Meckel's ganglion, and (3) the sympathetic.

Structure.—The tonsils are composed of lymphoid tissue, which is partly collected at intervals so as to form lymphoid nodules or follicles, and is partly diffused throughout a connective-tissue stroma. The nodules are ranged upon the sides of the crypts which penetrate into the organ, these crypts being lined with a prolongation of the mucous membrane on the inner surface, covered by stratified squamous epithelium. Lymph corpuscles migrate from the nodules into the crypts through the epithelium, and become salivary corpuscles. The nodules or follicles are surrounded by capillary networks and lymphatic plexuses. The tonsils also contain mucous glands, which open upon the walls of the crypts.

The Nasal Fossæ.

The nasal fossæ extend from the anterior nares to the posterior nares. Anteriorly they open upon the face, and posteriorly they open into the naso-pharynx. Each fossa is narrow above, but expanded below. It presents two walls, outer and inner, a roof, and a floor. The **outer wall** is rendered very irregular by three convoluted bony eminences, disposed antero-posteriorly, which bulge into the fossa. These are the superior and inferior turbinate processes of the ethmoid, and the inferior turbinate bone. They are also known as the superior, middle, and inferior spongy bones, or **conchæ.** They overhang deep channels, which are known as the **meatûs**—superior, middle, and inferior respectively.

The **superior meatus** is confined to the back part of the outer wall, and lies between the superior and middle conchæ. It is short and oblique, and opening into it there are (1) the spheno-palatine foramen, which leads from the spheno-maxillary fossa, and (2) the posterior ethmoidal cells, by one or more openings. Above and behind the superior concha is a depression, called the *spheno-ethmoidal recess*, into which the sphenoidal air-sinus opens.

The **middle meatus** is situated between the middle and inferior conchæ, is directed from behind forwards, and is overhung by the middle concha. Anteriorly it describes a bend, and passes upwards under cover of the front part of the middle concha, to be continued into the *infundibulum*, which leads from the frontal air-sinus of the corresponding side. The openings into the middle meatus are as follows: (1) the infundibulum, leading from the frontal air-sinus; (2) the opening of the anterior ethmoidal cells; (3) the opening of the maxillary air-sinus or antrum of Highmore; and (4) one or two openings of the middle ethmoidal cells. These various openings

are concealed by the middle concha. When this is removed the lateral wall of the middle meatus is seen to present a deep curved groove, called the **hiatus semilunaris,** which is directed downwards and backwards from the lower end of the infundibulum. Behind and above this hiatus there is a round prominence, called the **bulla ethmoidalis.** The opening of the anterior ethmoidal cells is situated in the vertical portion of the hiatus semilunaris, and the opening of the antrum of Highmore, which is of small size, is placed

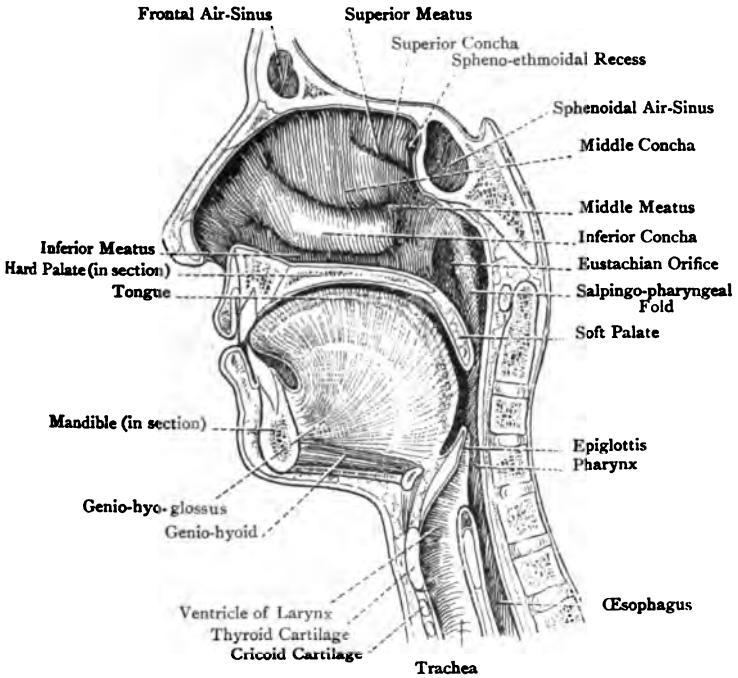


FIG. 495.—SAGITTAL SECTION THROUGH THE NASAL FOSSA, MOUTH, PHARYNX, ŒSOPHAGUS, AND LARYNX.

(The Outer Wall of the Right Nasal Fossa is shown).

in its horizontal portion, whilst the middle ethmoidal cells open above the bulla ethmoidalis. In front of the middle meatus is the region known as the **atrium,** which communicates anteriorly with the **vestibule,** the latter being situated just within the ala of the nostril.

The **inferior meatus** is situated below the inferior concha. Opening into its anterior part, under cover of the inferior concha, is the lower orifice of the nasal duct, which is provided with an imperfect mucous fold, called the **valve of Hasner.** The orifice is about 1¼ inches from the anterior nasal aperture.

The **inner wall** forms the *septum nasi*.

The **roof**, which is narrow, is horizontal in its central part, the anterior portion being sloped downwards and forwards, and the posterior portion downwards and backwards.

The **floor** is smooth, and at its anterior and inner part is the incisor foramen, into which a funnel-shaped portion of the mucous membrane extends. This region represents the wide communication which existed in early life between the nasal and buccal cavities.

Each nasal fossa is divided into three regions—vestibular, olfactory, and respiratory. The **vestibular region**, or **vestibule**, forms the anterior and lower part contiguous to the nostril. It is covered by skin, which is provided with hairs or *vibrissæ*. The **olfactory**

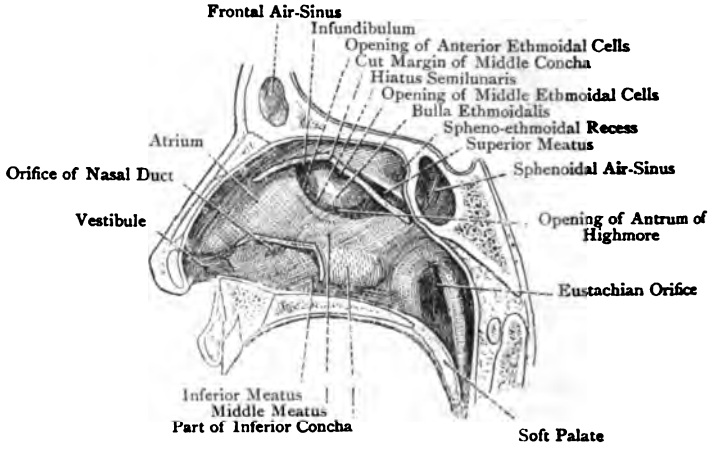


FIG. 496.—THE OUTER WALL OF THE RIGHT NASAL FOSSA.

(The Superior and Middle Conchæ and part of the Inferior Concha have been removed).

region is situated superiorly, and corresponds to the superior concha and the upper third of the septum nasi. The **respiratory region** comprises the middle and inferior conchæ, the middle and inferior meatûs, and the corresponding part of the septum.

Mucous Membrane.—With the exception of the vestibule, which is lined with skin, the nasal fossa is provided with a highly vascular and sensitive mucous membrane, called the **pituitary** or **Schneiderian membrane.** It is continuous through the posterior nares with the mucous membrane of the naso-pharynx; with that of the nasal duct, lachrymal sac, and lachrymal canaliculi, and thence with the conjunctiva; and with that of the various air-sinuses which communicate with the nasal fossa. It is thick and spongy over the conchæ, especially along the lower borders of the middle

and inferior conchæ, and also on the septum nasi, but over the floor, atrium, and meatûs it is comparatively thin. It is freely provided with acinous glands, and contains a certain amount of lymphoid tissue.

The epithelium varies in different regions. In the vestibular region, where the lining membrane is skin, the epithelium is of the stratified squamous variety ; in the respiratory region, as well as in

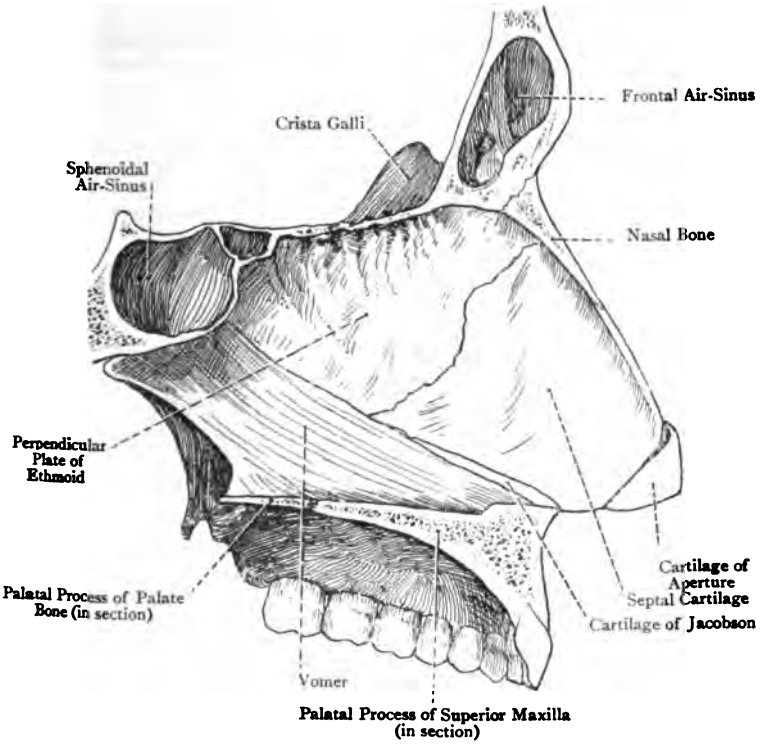


FIG. 497.—THE OSSEOUS AND CARTILAGINOUS NASAL SEPTUM (RIGHT LATERAL VIEW).

the air-sinuses, it is stratified, columnar, ciliated epithelium ; and in the olfactory region it is non-ciliated columnar epithelium.

Olfactory Mucous Membrane.—In the olfactory region the mucous membrane is thick and pulpy, and has a yellowish-brown colour, due to pigment in the epithelial cells. It contains a copious plexus of olfactory nerve-fibres, and many serous glands, which are known as the **glands of Bowman.** The **epithelium** is thick, and, as just stated, is of the non-ciliated columnar variety, its free surface being covered by a delicate limiting membrane. The cells

of which it is composed are of three kinds. (1) Long columnar nucleated cells, called the **sustentacular cells,** the deep ends of which are prolonged each into a branched process. (2) Between these sustentacular cells there are the olfactory cells, which are elongated and spindle-shaped. Each contains an almost spherical nucleus, and has a superficial and a deep process or pole. The *superficial pole* extends through the limiting membrane to the free surface, and projects slightly in the form of a tuft of delicate hair-like filaments called the **olfactory hairs.** The *deep pole,* which is a delicate varicose filament, extends towards the mucosa, where it becomes continuous with one of the nerve-fibrils of the olfactory

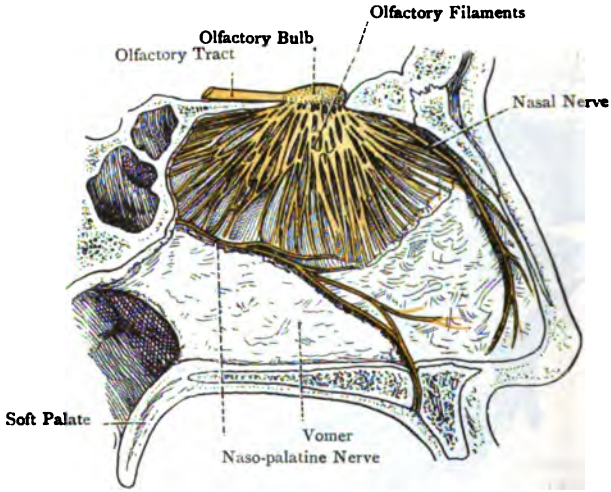


FIG. 498.—THE NERVES OF THE NASAL SEPTUM (HIRSCHFELD AND LEVEILLÉ).

plexus. (3) In the deep part of the epithelium there are in some places **conical cells,** the broad ends of which rest upon the basement membrane.

Olfactory Nerves.—These are from fifteen to twenty in number on each side. After leaving the inferior surface of the olfactory bulb, they pass through the foramina in the corresponding half of the cribriform plate of the ethmoid bone, and so reach the upper part of the nasal fossa, invested by prolongations of the membranes of the brain. Within the nasal fossa they are arranged in two groups, inner and outer. The nerves of the *inner group* are distributed to the mucous membrane of the septum nasi over about its upper third. The nerves of the *outer group* are distributed to the mucous membrane in the region of the superior concha and olfactory sulcus. The nerves form a copious plexus in the mucous membrane, and the filaments which issue from this plexus become continuous, as

stated, with the deep poles of the olfactory cells. The olfactory nerves are destitute of a medullary sheath.

Nerves of Ordinary Sensation.—These are derived from the ophthalmic and superior maxillary divisions of the fifth cranial nerve, and are as follows :

1. Superior nasal nerves.
2. Nasal branches of the Vidian nerve.
3. Inferior nasal nerves.
4. Internal branches of the nasal nerve.
5. Nasal branch of the anterior superior dental nerve.
6. Naso-palatine nerve.

The **superior nasal nerves** are derived from Meckel's ganglion. They enter the superior meatus through the spheno-palatine foramen, and are distributed to the mucous membrane (1) over the superior and middle conchæ, (2) over the upper and back part of the septum nasi, and (3) within the posterior ethmoidal cells.

The **nasal branches of the Vidian nerve** pierce the floor of the pterygoid or Vidian canal, and are distributed to the mucous membrane over the back part of the roof of the nasal fossa and the adjacent part of the septum.

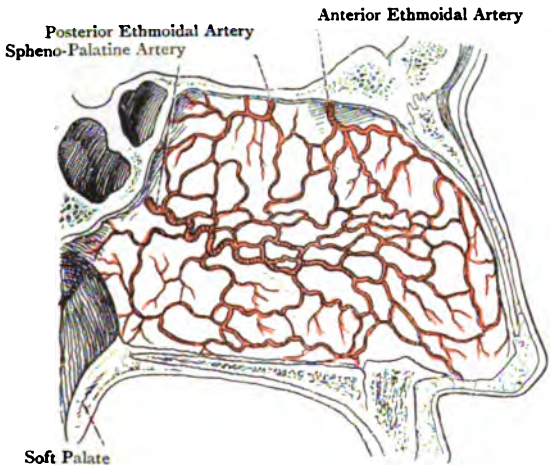


FIG. 499.—THE ARTERIES OF THE NASAL SEPTUM (HIRSCHFELD AND LEVEILLÉ).

The **inferior nasal nerves** arise from the great or anterior descending palatine branch of Meckel's ganglion, as that nerve traverses the posterior palatine canal. They enter the nasal fossa through foramina in the vertical plate of the palate bone, and are distributed to the mucous membrane over the greater part of the inferior concha, and the corresponding parts of the middle and inferior meatûs.

The **internal branches of the nasal nerve** are two in number, septal and external. The *septal branch* is distributed to the mucous membrane over the anterior and upper part of the septum, and the *external branch* to that over the anterior portions of the middle and inferior conchæ, and over the outer wall in front of these.

The **nasal branch of the anterior superior dental nerve** is distributed to the mucous membrane over the anterior part of the inferior meatus and the adjacent part of the floor of the nasal fossa.

The **naso-palatine nerve,** or **nerve of Cotunnius,** arises from Meckel's ganglion, and enters the nasal fossa through the spheno-palatine foramen. It then crosses the roof, and so reaches the septum, upon which it descends, with a forward inclination, occupying the groove on the outer surface of the vomer. Thereafter it passes downwards to the anterior part of the hard palate, the *left* nerve traversing the anterior foramen of Scarpa, and the *right* nerve the posterior foramen of Scarpa. As the naso-palatine nerve lies upon the septum nasi it furnishes branches to its mucous membrane.

Arteries of the Nasal Fossa.—These arteries are derived from the following sources :

1. The spheno-palatine.
2. The descending palatine.
3. The Vidian.
4. The anterior ethmoidal.
5. The posterior ethmoidal.
6. The superior coronary.

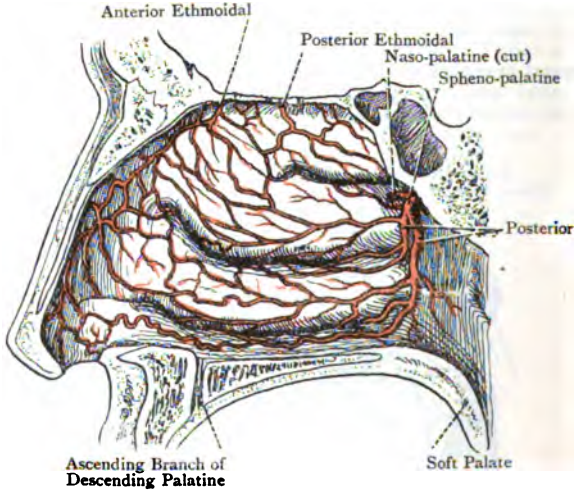


FIG. 500.—THE ARTERIES OF THE EXTERNAL WALL OF THE RIGHT NASAL FOSSA (AFTER HIRSCHFELD AND LEVEILLÉ).

The **spheno-palatine artery** is the principal artery of the nasal fossa. Arising from the third part of the internal maxillary, it enters the fossa through the spheno-palatine foramen. Most of its branches are distributed to the outer wall ; but one, called the *naso-palatine branch*, accompanies the naso-palatine nerve. This branch gives offsets to the septum, and terminates by entering the incisor foramen, where it anastomoses with a branch of the descending palatine artery, which ascends from the palate in the incisor canal (Stensen's canal).

The **descending palatine artery** arises from the third part of the internal maxillary. As it traverses the posterior palatine canal it gives off two or three branches which accompany the inferior nasal nerves through foramina in the vertical plate of the palate bone, to be distributed to the back part of the inferior concha and the adjacent parts of the middle and inferior meatus.

The **Vidian artery,** arising from the third part of the internal maxillary, traverses the pterygoid or Vidian canal, and furnishes a few twigs which accompany the nasal offsets of the Vidian nerve, and supply the back part of the roof of the nasal fossa and the adjacent part of the septum.

The **anterior** and **posterior ethmoidal arteries** are branches of the ophthalmic. The *anterior ethmoidal* enters the nasal fossa along with the nasal nerve, and furnishes branches to the anterior and upper part of the septum, the front

part of the outer wall, and the anterior portions of the middle and inferior conchæ. The *posterior ethmoidal* furnishes nasal branches which enter the nasal fossa through some of the foramina in one half of the cribriform plate of the ethmoid bone, and are distributed to the roof and upper part of the septum.

The **superior coronary artery,** a branch of the facial, furnishes the *artery of the septum*, which supplies the anterior part of the septum and the columella nasi.

The **veins** form a copious plexus, especially over the inferior concha and the lower margin and back part of the middle concha. The vessels which carry away the blood from the plexus correspond to the various arteries, and their principal destination is threefold, namely, (1) the pterygoid plexus, (2) the superior ophthalmic vein, and (3) the facial vein. The ethmoidal veins, which open into the superior ophthalmic vein, communicate with the intracranial anterior meningeal veins and with the angular vein of the face by means of twigs which pass through minute apertures in the nasal process of the superior maxilla, and, it may be, through a small foramen in the nasal bone. In those cases where the foramen cæcum is pervious it transmits an emissary vein which passes between the intracranial superior longitudinal sinus and the veins of the roof of the nasal fossa.

Lymphatics.—These are very numerous, and form a plexus which has the following communications: (1) with the lymphatic spaces round the olfactory nerves, and through these with the subdural and subarachnoid spaces; (2) with the lymphatics of the naso-pharynx; and (3) with the lymphatics of the face.

For the development of the nasal fossæ see p. 1161.

Organ of Jacobson.—Jacobson's organ is rudimentary in man, but is well developed in ruminantia. It takes the form of a blind pouch, which is situated in the lower and anterior part of the septum nasi on either side. The minute orifice of the pouch lies above the recess or depression of mucous membrane which projects slightly into the upper end of Stensen's canal. The pouch extends upwards and backwards in the septum nasi for a very short distance, and terminates in a blind extremity. The cartilage of Jacobson lies underneath it. Jacobson's organ does not seem to perform any function in man. In those animals, however, in which it is well developed, *e.g.*, ruminantia, it receives two nerves, one of which is olfactory, the other being derived from Meckel's ganglion. Moreover, its epithelial lining is similar to that of the olfactory region of the nasal fossa, inasmuch as it contains olfactory cells, the deep poles of which are continuous with olfactory filaments. In such animals it acts as a supplementary organ of smell.

Development.—The organ of Jacobson is developed as a diverticulum of the epiblast at the lower and anterior part of the septum nasi, into which latter it grows.

The Pharynx.

The pharynx is situated behind the posterior nares, isthmus faucium, and larynx, and it extends from the basilar region of the base of the skull to the level of the lower border of the cricoid cartilage of the larynx, where it becomes continuous with the œsophagus. It is a musculo-aponeurotic tube, about 5 inches long, and it attains its greatest width between the base of the skull and the hyoid bone. Below the latter level it narrows, and is flattened

from before backwards, so as to assume the form of a transverse cleft, except during the act of deglutition.

Relations.—*Posteriorly* it rests upon the bodies and discs of the cervical vertebræ as low as the sixth, and the prevertebral muscles covered by the prevertebral fascia. Between it and the last-named fascia is the retropharyngeal space, which is occupied by connective tissue, but this is so loosely arranged that no obstacle is offered to the movement of the tube, and a post-pharyngeal abscess can readily diffuse itself. *Anteriorly* it communicates with (1) the nasal fossæ through the posterior nares, (2) the Eustachian tubes, (3) the

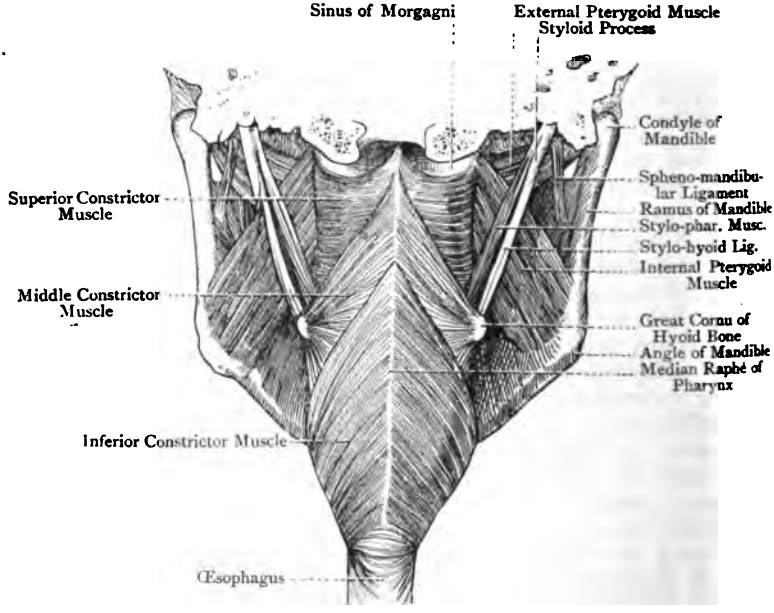


FIG. 501.—THE POSTERIOR WALL OF THE PHARYNX AND ADJACENT STRUCTURES.

buccal cavity through the isthmus faucium, and (4) the larynx. On this aspect its attachments are effected by means of the constrictor muscles in its walls. *Laterally* it is related to the principal bloodvessels and nerves of the neck, and comes into contact with the styloid muscles and the process from which they arise. *Superiorly* it is attached to the basilar region of the base of the skull. *Inferiorly* it is continuous with the œsophagus.

The wall of the pharynx consists of the following four strata, in order from without inwards: (1) the pharyngeal portion of the bucco-pharyngeal fascia, (2) the muscular coat, (3) the pharyngeal aponeurosis, and (4) the mucous coat.

Pharyngeal Fascia.—This is an offshoot of the prevertebral lamina of the deep cervical fascia along the mesial aspect of the carotid sheath. In front it becomes continuous with the fascia covering the buccinator muscle. In association with this fascial stratum there are many veins upon the posterior and lateral walls of the pharynx, which constitute the pharyngeal venous plexus.

Muscular Coat.—This is composed, on either side, of the three constrictor muscles, inferior, middle, and superior, the stylo-pharyngeus, and the palato-pharyngeus (including the salpingo-pharyngeus).

Inferior Constrictor—*Origin.*—(1) The side of the cricoid cartilage at its posterior part; (2) the inferior cornu and the oblique line of the ala of the thyroid cartilage; and (3) the upper border of the ala behind the superior tubercle.

Insertion.—The median raphé on the posterior wall of the pharynx, where it meets its fellow of the opposite side.

The lower fibres of the muscle are horizontal, but the upper fibres pass upwards and backwards more and more obliquely, and the highest fibres of the two muscles meet in the raphé to form a peak, which is about an inch below the basilar process of the occipital bone. The lower border of the muscle overlaps the upper end of the œsophagus, and, to a limited extent, some of the fibres are continuous with the œsophageal muscular fibres. The recurrent laryngeal nerve and inferior laryngeal artery pass upwards beneath the lower border behind the crico-thyroid joint. The upper border, which is very oblique, overlaps the lower portion of the middle constrictor, and the internal laryngeal nerve and the superior laryngeal artery, on their way to pierce the thyro-hyoid membrane, pass between the two muscles anteriorly.

Middle Constrictor—*Origin.*—(1) The upper surface of the great cornu of the hyoid bone over its entire length, (2) the small cornu, and (3) the hyoid extremity of the stylo-hyoid ligament.

Insertion.—The median raphé on the posterior wall of the pharynx, where it meets its fellow of the opposite side.

The muscle is fan-shaped, and its fibres consequently diverge very much as they pass round to reach the raphé. The inferior fibres descend very obliquely, and are overlapped by the upper fibres of the inferior constrictor, the internal laryngeal nerve and superior laryngeal artery passing to the thyro-hyoid membrane between the two muscles anteriorly. The middle fibres pass more or less transversely. The superior fibres ascend obliquely, and reach the basilar process of the occipital bone. They overlap the lower portion of the superior constrictor, and the stylo-pharyngeus muscle and glosso-pharyngeal nerve pass between the two. The lingual artery rests upon the muscle at the great cornu of the hyoid bone.

Superior Constrictor—*Origin.*—(1) The lower third of the posterior border of the internal pterygoid plate, and the hamular process of the sphenoid bone; (2) the posterior aspect of the pterygo-mandibular ligament, along which it meets the buccinator muscle;

(3) the posterior extremity of the mylo-hyoid ridge of the lower jaw; (4) the mucous membrane of the mouth; and (5) the side of the tongue.

Insertion.—The median raphé on the posterior wall of the pharynx, where it meets its fellow of the opposite side. A few of the highest

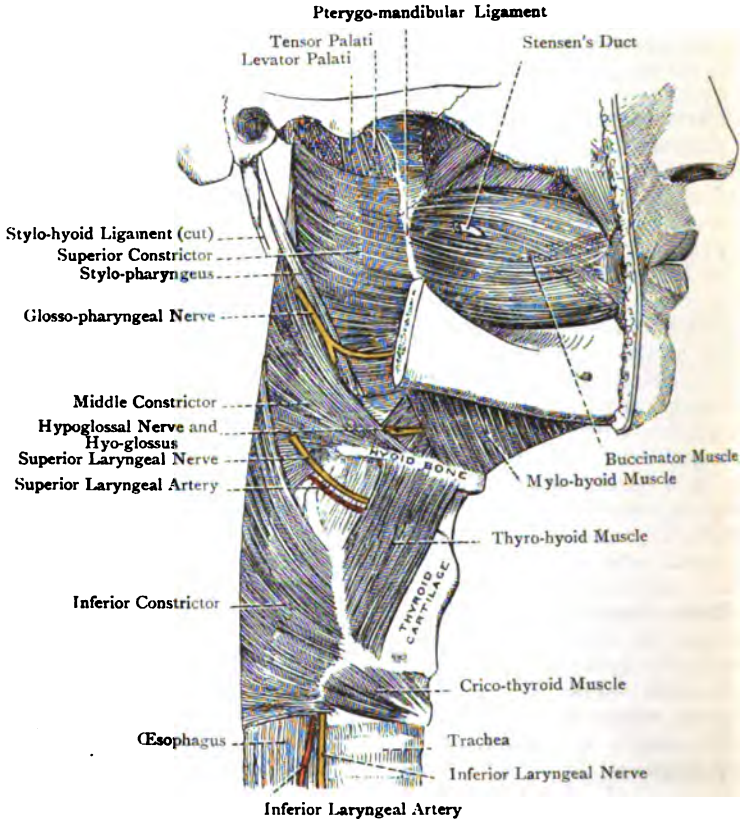


FIG. 502.—DISSECTION SHOWING THE CHEEK, PHARYNX, SUBMAXILLARY REGION, AND LARYNX (RIGHT VIEW).

fibres are inserted into the pharyngeal tubercle on the under surface of the basilar process of the occipital bone.

The muscle is somewhat four-sided. The fibres for the most part pass horizontally, but the lower fibres radiate in a downward direction, whilst the upper fibres curve backwards and upwards. The lower portion of the muscle is overlapped by the upper part of the middle constrictor, the stylo-pharyngeus muscle and glosso-pharyngeal nerve passing between the two. Between the upper

concave border and the base of the skull there is an interval, occupied by the pharyngeal aponeurosis, which is here stronger than elsewhere, and so compensates for the absence of muscular fibres. This interval is semilunar, and is known as the **sinus of Morgagni.**

Nerve-supply of the Constrictor Muscles.—The nerves are derived from the pharyngeal plexus, which is formed by the pharyngeal branch of the pneumogastric, the pharyngeal branches of the glosso-pharyngeal, and sympathetic filaments. The motor fibres of the plexus are derived from the pharyngeal branch of the pneumogastric, but their ultimate source is the **bulbar portion of the spinal accessory nerve.** The inferior constrictor muscle also receives twigs from (1) the external laryngeal branch of the superior laryngeal nerve, and (2) the inferior or recurrent laryngeal nerve as it passes beneath the lower border of the muscle.

Action.—The constrictor muscles are concerned in the act of deglutition. The superior constrictor and upper portion of the middle constrictor act upon the naso-pharynx, that is, the compartment of the pharynx which lies above the soft palate, and is in communication with the nasal fossæ through the posterior nares. They narrow the naso-pharynx in the lateral direction, and this movement, in conjunction with the action of the posterior pillars of the fauces, shuts off the naso-pharynx, thus preventing regurgitation into and through the nasal fossæ. The lower portion of the middle constrictor and the inferior constrictor diminish the calibre of the buccal compartment of the pharynx. Coming into action during the second stage of deglutition, they grasp the bolus of food and press it downwards into the œsophagus. The constrictor muscles contract rapidly, and in order from above downwards.

For a description of the stylo-pharyngeus and palato-pharyngeus muscles (including the salpingo-pharyngeus), see pp. 1143 and 1170.

Pharyngeal Aponeurosis.—This is situated between the muscular coat and the mucosa. Inferiorly it is weak and indistinct, but superiorly it acquires greater firmness and density, especially where it is attached to the basi-occipital, the apex of the petrous part of the temporal bone, the adjacent portion of the Eustachian tube, and the internal pterygoid plate of the sphenoid bone. It receives an accession of strength in the median line from a strong bundle of fibres which descends from the pharyngeal tubercle on the under surface of the basilar process of the occipital bone, and which form the raphé of the pharynx.

Interior of the Pharynx.—The mucous membrane, which forms the fourth stratum in the pharyngeal wall, is of a papillary character, and has the following important continuations: (1) with the mucous membrane of the Eustachian tube, and thence with that of the tympanum or middle ear; (2) with that of the nasal fossæ through the posterior nares; (3) with that of the buccal cavity through the isthmus faucium; (4) with that of the larynx through the superior laryngeal aperture; and (5) with that of the œsophagus. At its upper and back part it is richly provided with lymphoid tissue,

to be presently referred to, and in the submucous tissue there are many acinous glands of a mucous character.

The soft palate projects into the cavity of the pharynx in a downward and backward direction, and divides it into two regions, upper and lower. The upper region is known as the naso-pharynx, and is in communication with the nasal fossæ and Eustachian tubes. It also communicates with the lower region by means of the **pharyngeal isthmus.** The lower region is subdivided into two

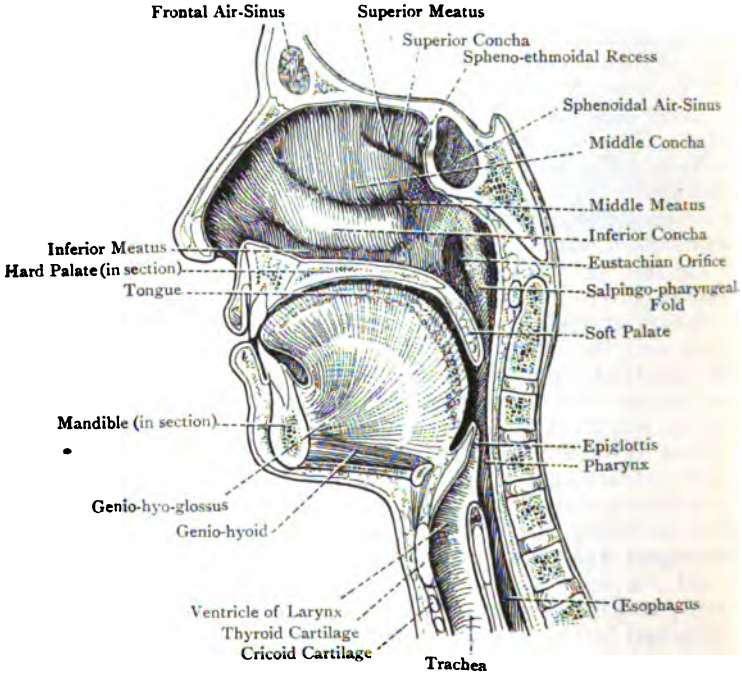


FIG. 503.—SAGITTAL SECTION THROUGH THE NASAL FOSSA, MOUTH, PHARYNX, ŒSOPHAGUS, AND LARYNX.

(The Outer Wall of the Right Nasal Fossa is shown).

parts, buccal and laryngeal. The buccal part is limited above by the soft palate, and below by the superior aperture of the larynx, and it communicates with the buccal cavity through the isthmus faucium. The laryngeal part is situated behind the larynx, with which it communicates, as well as with the œsophagus inferiorly.

Naso-pharynx.—This is entirely respiratory in function, and is consequently always pervious. It is bounded in front by the posterior nares and the posterior border of the vomer; behind, by the vertebral column; above, by the basilar process of the occipital

and part of the body of the sphenoid ; and below by the soft palate, which can be elevated and depressed. Four openings communicate with the naso-pharynx. The anterior wall presents the oval openings of the posterior nares leading from the nasal fossæ, and separated from each other by the posterior border of the vomer. Each opening in the recent state measures about 1 inch from above downwards, and about ½ inch from side to side. Through it, on the outer wall of the corresponding nasal fossa, are seen the posterior parts of the inferior turbinate bone and the inferior turbinate

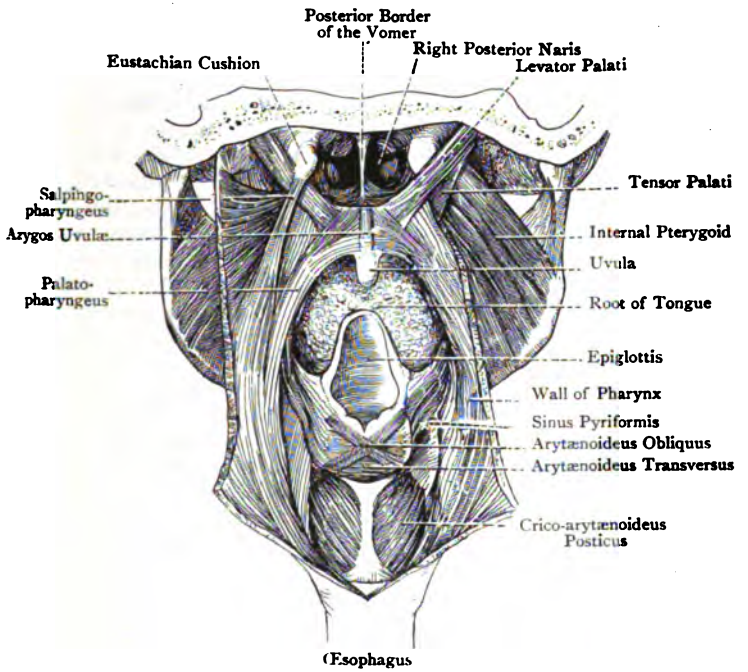


FIG. 504.—THE PHARYNX OPENED FROM BEHIND.

process of the ethmoid bone, covered by mucous membrane ; and above and below the inferior turbinate bone are seen the posterior parts of the middle and inferior meatûs. The orifice of the Eustachian tube is situated on each lateral wall, behind and external to the corresponding posterior naris, and on the same level as the posterior end of the inferior turbinate bone. It is somewhat oval, and presents, above and behind, a prominent round border, formed of cartilage, called the *cushion*. Behind the cushion there is a deep pouch on the lateral wall of the naso-pharynx, called the **lateral pharyngeal recess,** or **fossa of Rosenmüller,** which represents the upper part of the pharyngeal portion of the second visceral cleft. The mucous membrane extending between the lateral pharyngeal

recesses, at the upper and back part, presents a number of folds containing a large amount of lymphoid tissue, which constitute the **pharyngeal tonsil.** When enlarged this mass is liable to obstruct the Eustachian orifices, and even the posterior nares. At the lower part of the pharyngeal tonsil there may be seen a small median recess, called the **pharyngeal bursa,** which leads upwards and backwards towards the pharyngeal tubercle on the basilar process of the occipital bone.

The mucous membrane is covered by ciliated columnar epithelium.

Buccal Part of the Pharynx.—This part is situated between the soft palate and the superior aperture of the larynx. Anteriorly it communicates with the buccal cavity through the isthmus faucium, below which is the root of the tongue. Each lateral wall presents the posterior pillar of the fauces, the interval between the two pillars corresponding to the pharyngeal isthmus. In front of each posterior pillar is a triangular depression which lodges the tonsil.

Laryngeal Part of the Pharynx.—This part is situated behind the larynx. Anterior to it there are the epiglottis, the superior aperture of the larynx, on either side of which is a recess called the **sinus pyriformis,** and the posterior parts of the arytenoid and cricoid cartilages, with the muscles related to them. It communicates with the larynx anteriorly and the œsophagus inferiorly.

The mucous membrane of the buccal and laryngeal portions is covered by stratified squamous epithelium.

Blood-supply.—The **arteries** of the pharynx are derived from several sources, *e.g.*, the ascending pharyngeal branch of the external carotid, the inferior or ascending palatine and tonsillar branches of the cervical part of the facial artery, and the descending palatine and pterygo-palatine branches of the internal maxillary.

The **veins** form a copious *pharyngeal plexus,* which is disposed upon the lateral and posterior walls of the pharynx. It communicates superiorly with the pterygoid venous plexus, and receives tributaries from the soft palate, tonsils, and Eustachian tubes. Inferiorly the blood is conveyed from it into the internal jugular vein directly, or through means of the common facial vein.

Lymphatics.—The lymphatic vessels from the upper part of the pharynx pass to the internal maxillary glands, which are associated with the lateral walls of the tube, and those from the remaining part pass to the upper group of deep cervical glands. Some of the lymphatics from the upper part pass to the **retropharyngeal glands,** two in number, each of which lies upon the upper part of the corresponding rectus capitis anticus major muscle.

Development of the Pharynx, and of the Visceral Clefts and Visceral Arches.

The pharynx is developed from the anterior or cephalic part of the fore-gut. On the ventral wall of this part there are two elevations, the anterior of which is called the **tuberculum impar,** whilst the posterior is called the **furcula.** The latter has the form of a horseshoe, the open part of which is

placed posteriorly. The furcula is separated from the tuberculum impar in front, and from the lateral wall of the fore-gut on either side, by a groove called the **sinus arcuatus.** The tuberculum impar gives origin to the anterior two-thirds, or buccal portion, of the tongue; the anterior part or loop of the furcula gives rise to the epiglottis; the posterior extremities of the furcula to the arytenoid cartilages; and the depression within the furcula becomes deepened and developed into the larynx and trachea. Posterior to the furcula the foregut becomes dilated to form the rudimentary stomach, and as this descends the œsophagus is formed.

Visceral Clefts and Visceral Arches.—On each lateral wall of the anterior part of the fore-gut four protrusions of hypoblast take place, to meet which the epiblast dips in, and so four clefts are formed, called the **visceral clefts,** first, second, third, and fourth, from before backwards. The parts of the lateral wall of the fore-gut between the four visceral clefts, the part forming the anterior margin of the first visceral cleft, and the part forming the posterior margin of the fourth visceral cleft, become thickened by the growth of mesoblast between their hypoblastic and epiblastic layers. In this manner

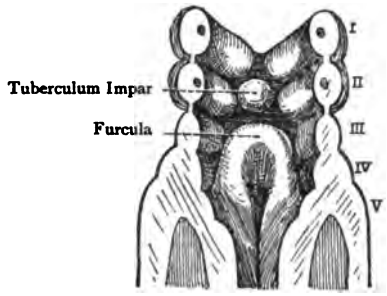


FIG. 505.—THE VISCERAL ARCHES OF THE EMBRYO (POSTERIOR VIEW) (HIS).

I. Mandibular Arch
II. Hyoid Arch
III. Thyro-hyoid Arch
IV. Fourth Arch
V. Fifth Arch

(in the higher vertebrata), five round, curved bars are formed, called the **visceral arches,** each of which has a cartilaginous framework.

The **first** or **mandibular arch** is placed in front of the first visceral cleft, between it and the mouth, and for the most part it gives rise to the mandible, or inferior maxilla. The **maxillary process** is an outgrowth from it superiorly, and gives rise to the principal part of the superior maxilla (exognathion), the malar and palate bones, and, it may be, the internal pterygoid plate of the sphenoid. The skeletal framework of the mandibular arch is known as **Meckel's cartilage.** Its upper part gives rise to the malleus, and, according to some authorities, the incus, and its lower part to the symphysial part of the mandible or inferior maxilla. The intermediate portion disappears, but the fibrous investment of the upper part of this intermediate portion persists as the spheno-mandibular ligament, and that of its lower part gives rise to the chief portion of the mandible or inferior maxilla. The mandibular arch also gives origin to the tragus, and part of the helix, of the auricle.

The **second** or **hyoid arch** is situated between the first and second visceral clefts, and the **third** or **thyro-hyoid arch** between the second and third visceral clefts. These arches on either side join, and the two united portions, blending in the median line, give rise to a transverse eminence in the anterior part of the sinus arcuatus, between the tuberculum impar and the anterior part or loop of the furcula. This transverse eminence gives rise to the posterior third or pharyngeal portion of the tongue. The skeletal cartilaginous framework of the hyoid arch is known as the **hyoid bar.** Its lower part gives rise

to part of the body, and the whole of the small cornu, of the hyoid bone, and its upper part to the styloid process (both tympano-hyal and stylo-hyal portions) of the temporal bone. The fibrous investment of the intermediate portion persists as the stylo-hyoid ligament. The hyoid arch also gives rise to a part of the helix, antihelix, antitragus, and lobule, of the auricle, and, according to some authorities, to the incus. The lower part of the cartilaginous bar of the third or thyro-hyoid arch gives rise to the great cornu and adjacent portion of the body of the hyoid bone, and the remainder of it disappears. The **fourth visceral arch,** of small size, is situated between the third and fourth visceral clefts, and the **fifth,** which is very small, forms the posterior margin of the fourth visceral cleft. The ventral portion of the cartilaginous bars of these two arches become united with those of the opposite side by a median plate, and they are regarded as giving rise to the thyroid cartilage of the larynx. The remaining portions of the bars disappear.

The hypoblast of the **first visceral cleft** becomes developed into the Eustachian tube and tympanum, and its epiblast forms the meatus auditorus externus. The **second visceral cleft** persists as the supratonsillar fossa. The **third** and **fourth visceral clefts,** right and left, give origin internally to the diverticula, from which the thymus body is developed. The **fourth visceral cleft** of each side gives origin internally to the diverticulum from which the corresponding lateral lobe of the thyroid body is developed.

Eustachian Tube.

The Eustachian tube leads from the tympanum to the naso-pharynx, and is about 1½ inches in length. It is directed forwards, inwards, and slightly downwards, and is composed of two parts, osseous and cartilaginous. The osseous or postero-external part is about ½ inch long, and represents the lower or Eustachian compartment of the canal situated in the angle between the petrous and squamous parts of the temporal bone. The cartilaginous or antero-internal part is about 1 inch in length, and lies in the groove between the great wing of the sphenoid and the apical portion of the petrous part of the temporal bone. It is at first narrow, but gradually enlarges, so as to resemble a trumpet. The narrowest portion of the whole tube is at the junction of the osseous and cartilaginous parts, this being known as the **isthmus,** and the widest part is at the pharyngeal orifice. The roof, inner wall, and upper part of the outer wall of the cartilaginous part consist of a triangular plate of cartilage, the margins of which are slightly rolled towards each other. The floor and most of the outer wall are formed of a dense fibrous membrane. The **pharyngeal orifice** of the tube is expanded, and is situated on the lateral wall of the naso-pharynx behind, and external to, the corresponding posterior naris, and on the same level as the posterior end of the inferior turbinate bone. It is somewhat oval, and presents, above and behind, a prominent border, formed by the thick margin of the cartilage, and called the **cushion.** Posterior to this is the lateral pharyngeal recess or fossa of Rosenmüller.

The tube is lined with mucous membrane, which is continuous with that of the tympanum on the one hand, and with that of the naso-pharynx on the other. It is thin in the osseous part of the tube, but in the cartilaginous part it is thick, and contains mucous

glands and lymphoid tissue. It is covered by stratified columnar ciliated epithelium.

Muscles connected with the Eustachian Tube.—The **levator palati** has an origin from the lower margin of the cartilage of the tube, the **tensor palati** from the outer side of the cartilage, and the **salpingo-pharyngeus** is attached to the lower and front part of the tube. During deglutition the orifice of the tube is usually regarded as being kept open. According to Cleland, however, who had unusual opportunities of examining matters on the living person, 'the anatomical facts make it evident that any dilating influence of the tensor palati is exercised on the hinder and smaller part of the tube, whilst the levator palati closes the anterior (that is, pharyngeal) orifice' by raising the membranous floor of the tube.

Arteries.—These are derived from (1) the Vidian branch of the third part of the internal maxillary, and (2) the ascending pharyngeal branch of the external carotid.

Nerves.—The nerves are derived from (1) the tympanic plexus on the inner wall of the tympanum, and (2) the Vidian nerve.

Development.—The Eustachian tube is developed from the hypoblast of the first visceral cleft.

The Larynx.

The larynx is the upper part of the respiratory passage, being modified in structure so as to enable it to act as the organ of voice. It is situated in the median line of the neck above the trachea, and it lies opposite the fourth, fifth, and sixth cervical vertebræ. Superiorly it opens into the laryngeal portion of the pharynx, and inferiorly into the trachea. It is covered in front by the integument and the deep cervical fascia, and the laryngeal portion of the pharynx lies behind it. On either side it is in relation with the upper part of the lateral lobe of the thyroid body, the sterno-hyoid, omo-hyoid, sterno-thyroid, and thyro-hyoid muscles, and the common carotid artery.

Structure.—The larynx consists of a framework of cartilages, some of which are connected by joints and ligaments; it is provided with special muscles, spoken of as *intrinsic;* and it is lined with mucous membrane.

Cartilages.—These are nine in number, three being single and three arranged in pairs. The single cartilages are the epiglottis, the thyroid, and the cricoid, and the three arranged in pairs are the arytenoid, the cornicula laryngis, and the cuneiform.

The **epiglottis** is a leaf-like plate of yellow elastic fibro-cartilage, which stands bolt upright between the base of the tongue and the superior aperture of the larynx. Its lower part forms a narrow pedicle, which is attached to the receding angle of the thyroid cartilage, just below the median notch on its upper border, by means of a fibro-elastic band, called the **thyro-epiglottidean ligament.** Superiorly it presents a broad, round, free margin. Each lateral border is free above, but its lower part is contained within

the aryteno-epiglottidean fold of mucous membrane. The anterior or lingual surface is free over its upper part, where it faces the base of the tongue, and is covered by mucous membrane. This membrane is prolonged on to the base of the tongue as the **glosso-epiglottidean fold,** or **frenum epiglottidis,** which is mesially placed. It is also prolonged from the sides of the epiglottis on to the lateral walls of the pharynx as the **pharyngo-epiglottidean folds.** On either side of the frenum epiglottidis, between it and each

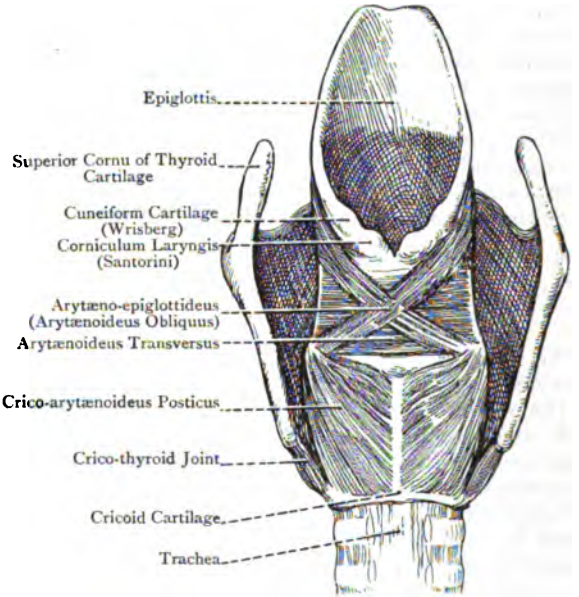


FIG. 506.—THE INTRINSIC MUSCLES OF THE LARYNX (POSTERIOR VIEW).

pharyngo-epiglottidean fold, there is a depression or fossa, which is known as the **vallecula.** Lower down than these folds the anterior surface is connected to the back of the upper border of the body of the hyoid bone by an elastic, semilunar membrane, called the **hyo-epiglottidean ligament.** Above the upper border of the thyroid cartilage the anterior surface is separated from the posterior aspect of the thyro-hyoid membrane by a collection of adipose and elastic tissues, which is known as the **periglottis** (epiglottidean gland). The posterior or laryngeal surface is free over its whole extent, and is covered by mucous membrane. It is concave from side to side, and concavo-convex from above downwards. The lower convexity forms the **cushion** or **pulvinar.** When the mucous membrane is removed the epiglottis presents a number of small glandular pits.

Thyroid Cartilage.—This cartilage is composed of two flat quadrilateral **alæ,** which meet in front by their anterior borders, but diverge widely behind. The angular projection formed by their union is called the **isthmus** or *pomum Adami*. The union is confined to about the lower half of each anterior border, and there is left superiorly a deep triangular cleft called the **thyroid notch.** The posterior border, of greater length than the anterior, is round, and gives attachment to fibres of the palato-pharyngeus and stylo-pharyngeus muscles. At either extremity it is prolonged into a projection, the superior cornu and inferior cornu respectively. The **superior cornu** gives attachment to the lateral thyro-hyoid ligament, and the **inferior cornu,** which is slightly incurved, is facetted on its inner aspect to articulate with the cricoid cartilage. The superior border is for

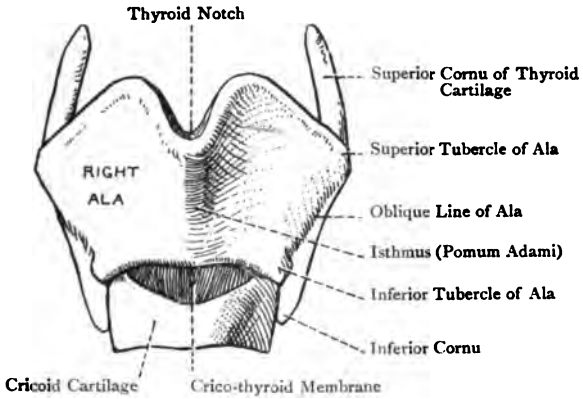


FIG. 507.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (ANTERIOR VIEW).

the most part convex, and near its back part it presents a slight eminence, called the **superior tubercle.** The inferior border is almost horizontal, and presents an eminence about the junction of the posterior third with the anterior two-thirds, called the **inferior tubercle.** It gives attachment to the median portion of the crico-thyroid membrane and the crico-thyroid muscle. The outer surface of the ala is marked by an oblique line, or, it may be, ridge, which extends downwards and forwards from the superior to the inferior tubercle. This line gives insertion to the sterno-thyroid, and origin to the thyro-hyoid, muscles. It divides the outer surface into two unequal parts, an anterior three-fourths and a posterior fourth, the latter giving origin to fibres of the inferior constrictor muscle. The inner surface of the ala is smooth, slightly concave, and covered by mucous membrane. In the median line, behind the pomum Adami, there is a vertical depression known as the **receding angle.** Commencing just below the thyroid notch on the upper border and passing downwards, this region gives attachment to the

following structures: (1) the thyro-epiglottidean ligament, (2) the superior thyro-arytenoid ligaments (false vocal cords), and (3) the inferior thyro-arytenoid ligaments (true vocal cords), in association with which are the fibres of the thyro-arytenoid muscles.

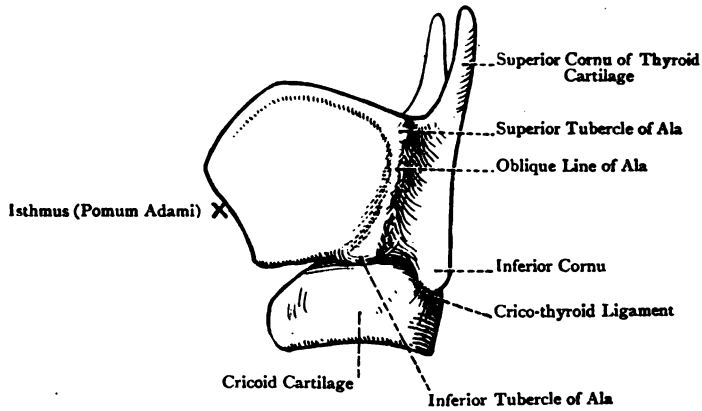


FIG. 508.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (LATERAL VIEW).

Development of the Thyroid Cartilage.—The thyroid cartilage is regarded as being developed from the ventral portions of the skeletal cartilages of the fourth and fifth visceral arches of either side, which become united by a median plate. The cornua of each ala represents the ununited portions of the cartilages of the corresponding visceral arches, and the connecting median plate represents the isthmus.

Cricoid Cartilage.—This is situated below the thyroid cartilage, and indicates the lower limit of the larynx. As its name implies, it resembles a ring. Its anterior part is narrow, and is about $\frac{1}{5}$ inch in depth. The inferior border is horizontal, and is connected by membrane to the trachea. The superior border is connected anteriorly to the lower border of the thyroid cartilage by the median portion of the crico-thyroid membrane. Posteriorly this border presents a slight excavation at the centre, and at either side an oval convex facet for articulation with the base of the arytenoid cartilage. The posterior portion is deep, which is brought about by the rapid elevation of the superior border as it is traced backwards. The posterior surface is somewhat quadrilateral. It presents a median vertical ridge, the upper part of which gives attachment to the longitudinal muscular fibres of the œsophagus. This ridge divides

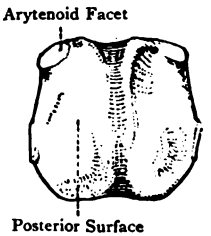


FIG. 509.—THE CRICOID CARTILAGE OF THE LARYNX (POSTERIOR VIEW).

it into two symmetrical halves, each of which gives origin to the posterior crico-arytenoid muscle. The outer surface of the cricoid cartilage presents posteriorly a circular facet for articulation with the inferior cornu of the thyroid cartilage. The upper sloping border of this part gives attachment, along its inner margin, to the lateral portion of the crico-thyroid membrane. The inner surface of the cricoid cartilage is covered by the mucous membrane of the larynx. It is to be noted that the anterior narrow part of the cartilage stands quite clear of the thyroid cartilage, whereas the deep posterior part, where the upward elevation takes place, is received between the diverging alæ of the thyroid cartilage.

Development.—The cricoid cartilage, like the rings of the trachea, is developed in the mesoblast of the respiratory tube.

Arytenoid Cartilages.—These cartilages, which are two in number, surmount the superior border of the cricoid cartilage posteriorly. Each has the form of a three-sided pyramid, and measures about ¼ inch in height, and about ¼ inch in width at the base. The apex looks upwards, and is curved in a backward and inward direction. It is surmounted by the corniculum laryngis. The base looks downwards, and is slightly concave and facetted to articulate with the superior border of the cricoid cartilage posteriorly. Two of the three angles of the base are prominent, namely, the anterior and the external. The **anterior angle,** somewhat pointed, is directed straight forwards, and is known as the *vocal process*. It gives attachment to the inferior thyro-arytenoid ligament or true vocal cord. The **external angle,** thick and somewhat round, has an inclination backwards, as well as outwards, and is known as the *muscular process*. Anteriorly it gives insertion to the crico-arytænoideus lateralis, and posteriorly to the crico-arytænoideus posticus. The surfaces are antero-external, posterior, and internal. The **antero-external surface,** a little above the vocal process, gives attachment to the superior thyro-arytenoid ligament or false vocal cord, and, above and external to the vocal process, to the thyro-arytænoideus muscle. The **posterior surface** is triangular and concave, and gives attachment to a portion of the arytænoideus muscle. The **internal surface** faces its fellow of the opposite side, and is covered by mucous membrane. It forms the posterior part of the lateral boundary of the rima glottidis. The borders are anterior, posterior, and external. The **anterior border** separates the internal from the antero-external surface, and terminates below in the vocal process. The **posterior border** separates the internal from the posterior surface.

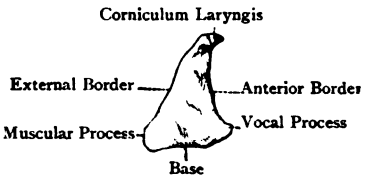


FIG. 510.—THE RIGHT ARYTENOID CARTILAGE AND CORNICULUM LARYNGIS (EXTERNAL VIEW).

The **external border** separates the antero-external from the posterior surface, and terminates below in the muscular process.

The thyroid and cricoid cartilages usually retain their cartilaginous condition up to about the twentieth year. In the case of the thyroid cartilage ossification proceeds from the inferior cornu, there being a special osseous nucleus in the region of the pomum Adami.

The anterior part and lower margin of the cricoid cartilage remain cartilaginous for some time, but the remainder undergoes ossification simultaneously with the thyroid cartilage.

Ossification of the arytenoid cartilages takes place at a later date than in the case of the two preceding cartilages.

Cornicula Laryngis or Cartilages of Santorini.—These are two small, somewhat conical nodules of yellow elastic cartilage which cap the apical parts of the arytenoid cartilages, their direction being backwards and inwards. Each lies within the aryteno-epiglottidean fold of mucous membrane.

Cuneiform Cartilages or Cartilages of Wrisberg.—These are two nodules of yellow elastic cartilage, which are situated, one on either side, in the aryteno-epiglottidean fold of mucous membrane at its back part, not far from the cornicula laryngis.

Ligaments of the Larynx—Thyro-hyoid Membrane.—This is a broad membranous sheet, which passes between the superior border of the thyroid cartilage and the back of the upper border of the body of the hyoid bone, as well as the deep surface of each great cornu. Its central and lateral portions are strong, and are composed chiefly of elastic tissue. The central portion is known as the *middle thyro-hyoid ligament*, its lower attachment being to the margins of the thyroid notch. The lateral portions, round and cord-like, are very elastic, and are known as the *lateral thyro-hyoid ligaments*. Each extends from the superior cornu of the thyroid cartilage to the tip of the great cornu of the hyoid bone, and enclosed within it, towards its upper part, there is a small nodule of cartilage called the **cartilago triticea.** Between the upper median portion of the thyro-hyoid membrane and the concave posterior surface of the body of the hyoid bone there is a synovial bursa. It is to be noted that the superior attachment of the thyro-hyoid membrane is such as to enable the upper part of the thyroid cartilage, when raised, to be received within the outline of the hyoid bone. The central portion of the membrane is subcutaneous, but on either side it is covered by the thyro-hyoid muscle. Beneath the posterior border of this muscle the internal laryngeal nerve and superior laryngeal artery pierce this membrane.

Crico-thyroid Membrane.—This membrane is composed of a median and two lateral portions. The **median portion** is composed chiefly of elastic tissue, and is attached to the adjacent borders of the cricoid and thyroid cartilages. It is subcutaneous in the median line, but laterally it is overlapped by fibres of the crico-thyroid muscles. Its centre is crossed by the crico-thyroid arterial arch, formed by the crico-thyroid branches of the superior thyroid arteries, and it presents a few openings for the passage of blood-

vessels. Through this portion laryngotomy may be performed. The **lateral portion** of the crico-thyroid membrane is connected below with the inner margin of the upper border of the lateral part of the cricoid cartilage. Superiorly it is not connected with the thyroid cartilage, but passes ***within*** its ala into the larynx, where it expands in an inward direction, and extends from the back of the ala of the thyroid cartilage in its lower part, close to the receding angle, to the under aspect of the vocal process of the arytenoid cartilage. Between these points it becomes continuous with the inferior thyro-arytenoid ligament or false vocal cord. The lateral portion of the crico-thyroid membrane (within the ala of the thyroid cartilage) is covered by the lateral crico-arytenoid and thyro-arytenoid muscles.

Superior Thyro-arytenoid Ligaments.—These form two small fibrous bands, one at either side, which lie within the folds of mucous membrane, called the false vocal cords. Each is attached

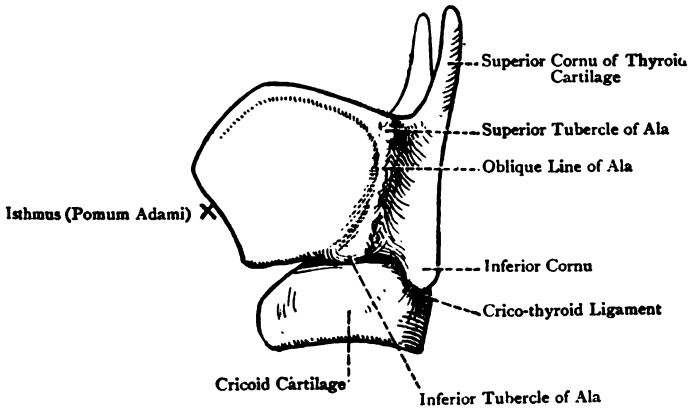


FIG. 511.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (LATERAL VIEW).

in front to the receding angle of the thyroid cartilage immediately below the attachment of the thyro-epiglottidean ligament, and behind to the antero-external surface of the arytenoid cartilage a little above the vocal process.

Inferior Thyro-arytenoid Ligaments.—These important ligaments, covered by mucous membrane, constitute the true vocal cords, and each is continuous with the upper part of the expanded lateral portion of the crico-thyroid membrane. Each is composed of yellow elastic tissue, and, with its fellow, is attached in front to the receding angle of the thyroid cartilage at its centre, and behind to the vocal process of the arytenoid cartilage. Its inner border, which is covered by mucous membrane, is free and clearly

defined. In its front part there is a small nodule of elastic cartilage called the *cartilage of Luschka* (Klein).

Crico-thyroid Joint.—This belongs to the class **diarthrosis.** The articular surfaces are the facet on the inner surface of the inferior cornu of the thyroid cartilage, and that on the outer surface of the cricoid cartilage posteriorly. The joint is surrounded by a capsular ligament, and this is lined with a synovial membrane. The **movements** allowed are as follows : (1) rotation of the thyroid cartilage round an axis passing transversely through both joints ; and (2) gliding, in which the cricoid moves upwards and backwards, or downwards and forwards, this movement partaking somewhat of a swinging character.

The recurrent laryngeal nerve ascends close behind the crico-thyroid joint preparatory to entering the larynx.

Crico-arytenoid Joint.—This belongs to the class **diarthrosis.** The articular surfaces are the convex facet on the superior border

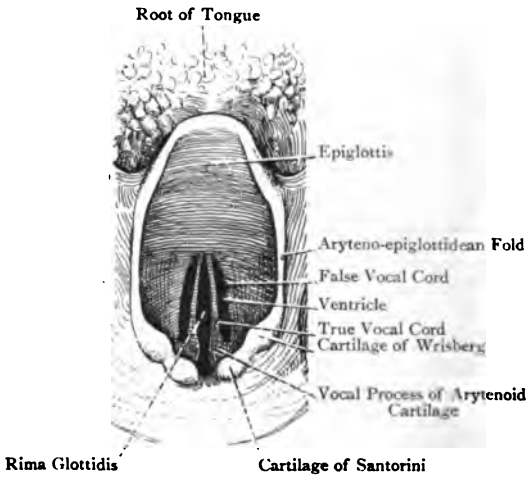


FIG. 512.—THE SUPERIOR APERTURE OF THE LARYNX AND ADJACENT PARTS.

of the cricoid cartilage posteriorly, and the concave under surface of the base of the arytenoid cartilage. The joint is surrounded by a capsular ligament, and this is lined with a synovial membrane. The **movements** allowed are as follows : (1) rotation, in which the arytenoid cartilage rotates on a nearly vertical axis, the effect being to invert, or evert, the vocal process; and (2) gliding in a lateral direction, in which one cartilage moves inwards towards its fellow, or outwards away from its fellow.

The cornicula laryngis are usually connected to the arytenoid cartilages by fibrous tissue, but in some cases there is a synovial articulation.

Interior of the Larynx.—The **superior aperture of the larynx** is situated behind and below the epiglottis. It is triangular, being wide in front and narrow behind, and its plane is sloped obliquely downwards and backwards. Above and in front it is bounded by the epiglottis, and behind by the fold of mucous membrane which stretches between the arytenoid cartilages. On either side are the prominent aryteno-epiglottidean folds, which extend from the tips of the arytenoid cartilages to the sides of the epiglottis and contain muscular fibres. Each of these folds, close to the arytenoid cartilage, contains the corniculum laryngis or cartilage of Santorini, which gives rise to a slight elevation, and a little in front of this it presents another slight elevation produced by the cuneiform cartilage or cartilage of Wrisberg. Between the arytenoid cartilage and the back part of the aryteno-epiglottidean fold internally and the back part of the ala of the thyroid cartilage externally there is a depression, opening upwards, called the **sinus pyriformis.** In this depression a foreign body may become lodged.

The **interior of the larynx** commences at the superior aperture and terminates on a level with the lower border of the cricoid cartilage. It is divided into three compartments by means of two antero-posterior folds of mucous membrane, which project into it from each lateral wall. The upper pair of folds are called the false vocal cords, and the lower pair the true vocal cords. The upper compartment is known as the **vestibule,** and it extends from the superior aperture down to the level of the false vocal cords. It is wider above than below, and its anterior depth exceeds the posterior. The middle or **ventricular compartment** is situated between the false vocal cords above and the true vocal cords below. On either side it presents a recess, called the **ventricle of the larynx** or **laryngeal sinus.** This is bounded above by a false vocal cord, and below by a true vocal cord. Its outer wall is covered externally by fibres of the thyro-arytenoid muscle. At the anterior part of the ventricle there is a small valvular aperture, which leads to a diverticulum of the ventricle, called the **laryngeal saccule** or **pouch.** This extends upwards between the false vocal cord and the ala of the thyroid cartilage, reaching as high as the upper border of the latter. On its inner aspect there are some muscular fibres,

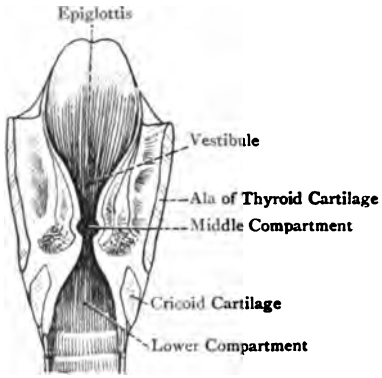


FIG. 513. — VERTICAL TRANSVERSE SECTION OF THE LARYNX, SHOWING THE POSTERIOR SURFACE OF THE ANTERIOR HALF OF THE ORGAN (MARSHALL).

which are known as the compressor sacculis laryngis or Hilton's muscle.

The **lower compartment** of the larynx is compressed from side to side above, but becomes circular inferiorly, where it opens into the trachea.

Vocal Cords.—These are arranged in two pairs, laterally disposed, called false and true, or superior and inferior.

The **superior** or **false vocal cords** are two folds of mucous membrane, which extend at either side from the receding angle of the thyroid cartilage immediately below the attachment of the thyro-epiglottidean ligament to the antero-external surface of the arytenoid cartilage, a little above the vocal process. Each contains

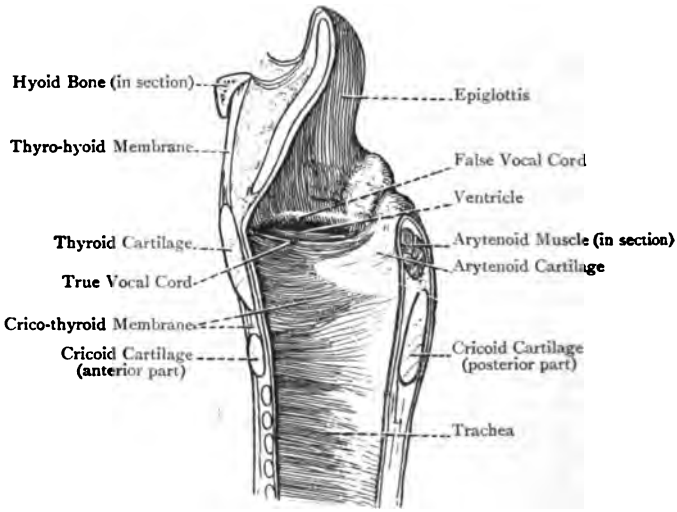


FIG. 514.—SAGITTAL SECTION OF THE LARYNX AND TRACHEA, SHOWING THE VOCAL CORDS AND VENTRICLE OF THE RIGHT SIDE.

some fibrous tissue forming the superior thyro-arytenoid ligament. The false vocal cords are widely separated from each other by an interval known as the *false glottis*, so that the true vocal cords are visible on looking into the larynx from above.

The **inferior** or **true vocal cords** are concerned in the production of the voice. They are prominent folds at either side, which are rather less than an inch in length, and extend from the receding angle of the thyroid cartilage to the vocal process of each arytenoid cartilage. Each cord consists of the inferior thyro-arytenoid ligament, which is continuous with the upper part of the expanded lateral portion of the crico-thyroid membrane, and is composed of yellow elastic tissue. The mucous membrane covering the cord is thin, and firmly adherent to the elastic tissue of the ligament.

and it has a characteristic pearly white colour. The true vocal cords are much nearer to each other than the false, so that the latter are not visible when the larynx is viewed from below.

Rima Glottidis.—The rima glottidis, or *glottis vera*, is the narrow fissure by which the upper and lower compartments of the larynx communicate with each other, and it is the narrowest part of the cavity. It is elongated from before backwards, and is narrow in front at the receding angle of the thyroid cartilage, but wider behind, where it is closed by the interarytenoid fold of mucous membrane. It is divisible into an interchordal portion, called the *glottis vocalis*, and an interarytenoid portion, called the *glottis respiratoria*. The glottis vocalis is narrow, and is bounded on either side by the true vocal cord. Its length, as stated, is rather less than an inch, and it forms about two-thirds of the entire glottis.

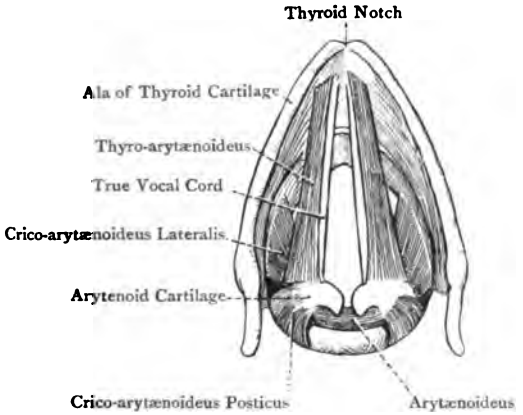


FIG. 515.—DISSECTION OF THE LARYNX, SHOWING THE MUSCLES, TRUE VOCAL CORDS, AND RIMA GLOTTIDIS (SUPERIOR VIEW).

The glottis respiratoria is wider than the glottis vocalis, and is bounded on either side by the inner aspect of the base of the arytenoid cartilage. It is about $\frac{1}{4}$ inch in length, and forms about one-third of the length of the entire glottis.

The shape of the rima glottidis is subject to alteration, and has to be considered under three conditions.

(1) During *quiet respiration* it has the form of an elongated triangle, the apex being in front at the thyroid cartilage, and the base behind at the interarytenoid fold of mucous membrane. (2) During a *deep inspiration* the rima is widely dilated, and assumes a somewhat diamond-shape, the widest part being opposite the tips of the vocal processes of the arytenoid cartilages, where the lateral angles of the diamond are placed, the posterior angle, at the interarytenoid fold of mucous membrane, being truncated. (3) During *vocalization*, *phonation*, and especially in *singing high*

notes, the vocal cords become so closely approximated as to be practically parallel, and the glottis vocalis assumes the form of a narrow chink.

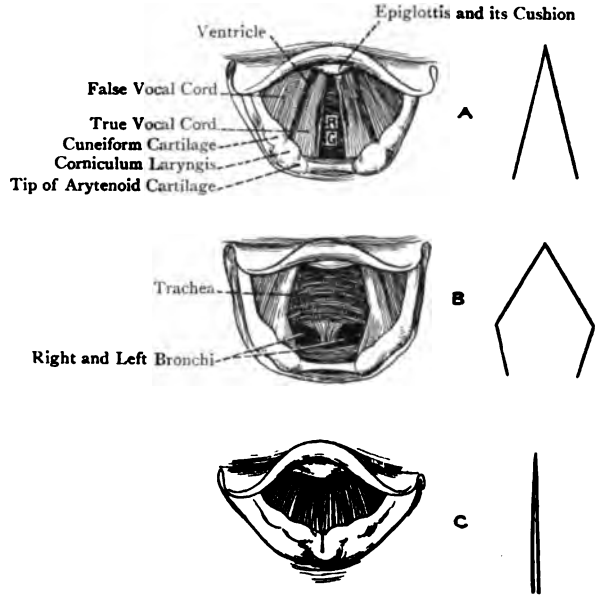


FIG. 516.—THE SUPERIOR APERTURE OF THE LARYNX AND THE RIMA GLOTTIDIS, AS SEEN BY THE AID OF THE LARYNGOSCOPE UNDER DIFFERENT CONDITIONS.

(The Figures on the left side are copied from Czermak).

A, Ordinary quiet inspiration
B, Very deep inspiration
C, Vocalization, especially in singing high notes
R.G. Rima Glottidis

Mucous Membrane of the Larynx.—This is continuous above with the mucous membrane of the pharynx, and below with that of the trachea. Above the level of the rima glottidis its subjacent attachment is of a loose nature on account of the presence of submucous areolar tissue, particularly in the vicinity of the aryteno-epiglottidean folds, a condition which favours the occurrence of œdema, but over the laryngeal surface of the epiglottis it is firmly attached. Over the true vocal cords it is very thin, and is firmly connected to the inferior thyro-arytenoid ligaments, which they contain. The membrane is covered by ciliated columnar epithelium, except (1) near the margin of the aryteno-epiglottidean folds, where it is of the stratified squamous variety, as in the laryngeal portion of the pharynx and the buccal cavity; and (2) over the true vocal cords, where it is also of the stratified squamous variety. Bodies resembling the taste-buds of the tongue are met with on the

laryngeal surface of the epiglottis, the inner surfaces of the arytenoid cartilages and of the aryteno-epiglottidean folds, and over the margins of the false vocal cords.

The mucous membrane contains a large number of acinous mucous glands, the ducts of which open freely on the surface, except over the true vocal cords, where there are no glands. They are arranged in groups, as follows: (1) epiglottidean, which are very numerous, and occupy the pits on the laryngeal surface of the epiglottis; (2) arytenoidean, in front of the arytenoid cartilages, and in the adjacent portions of the aryteno-epiglottidean folds; (3) along the false vocal cords; and (4) in the wall of the laryngeal saccule, where they are very numerous.

Intrinsic Muscles.—These are the muscles by which the cartilages are moved upon each other so as to affect the condition of the

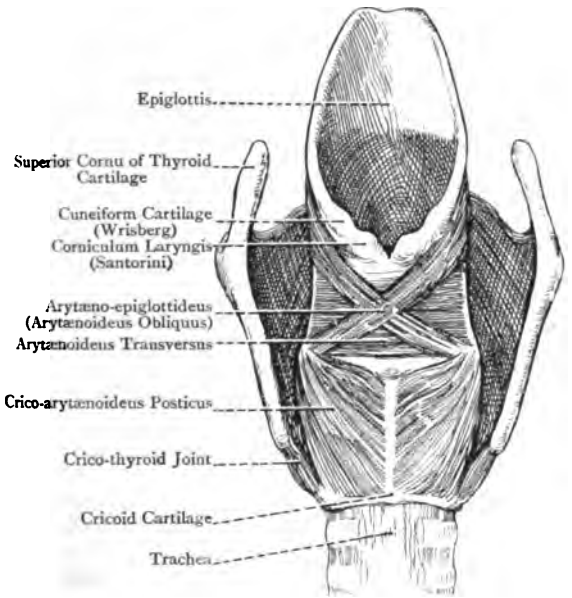


FIG. 517.—THE INTRINSIC MUSCLES OF THE LARYNX (POSTERIOR VIEW).

vocal cords. They are as follows: the crico-thyroid, posterior crico-arytenoid, lateral crico-arytenoid, arytenoid, and arytæno-epiglottideus. The arytenoid is a single muscle, but all the others are arranged in pairs.

Crico-thyroid—*Origin.*—The front of the anterior part of the cricoid cartilage, extending as far as the median line.

Insertion.—(1) The lower margin of the ala of the thyroid cartilage, and (2) the front of the inferior cornu.

Nerve-supply.—The external laryngeal branch of the superior laryngeal nerve.

The fibres are directed upwards and backwards in a diverging manner, the posterior being horizontal and the anterior oblique. These two sets of fibres are usually distinct.

Action.—To approximate the front parts of the cricoid and thyroid cartilages in the following manner : the posterior horizontal fibres draw the cricoid cartilage backwards, and the anterior oblique fibres elevate the anterior part of the cricoid cartilage, thus imparting a swinging movement to the cartilage. As a result of this movement the deep posterior part of the cricoid cartilage, with the arytenoid cartilages on its upper border, are depressed. In this manner the vocal cords are put upon the stretch, so that the muscles are tensors of the cords.

Between the two muscles anteriorly there is a triangular interval about $\frac{1}{2}$ inch wide, in which the central portion of the crico-thyroid membrane is visible, this portion being crossed at its centre by the crico-thyroid arch of arteries. In this region, just above the cricoid cartilage, laryngotomy may be performed.

Posterior Crico-arytenoid—*Origin.*—The posterior surface of the cricoid cartilage on one side of the median vertical ridge.

Insertion.—The posterior aspect of the muscular process or external angle of the base of the arytenoid cartilage.

Nerve-supply.—The recurrent laryngeal nerve.

The fibres of the muscle are directed upwards and outwards, the highest being short and nearly horizontal, the middle being oblique, and the lowest almost vertical.

Action.—To draw the muscular process of the arytenoid cartilage backwards and inwards, thereby swinging the vocal process or anterior angle outwards, the result of which is to open or widen the rima glottidis. The muscle is, therefore, a dilator of the rima glottidis.

The muscle is separated from its fellow by the median vertical ridge on the back of the cricoid cartilage.

Lateral Crico-arytenoid—*Origin.*—The lateral portion of the cricord cartilage along its upper sloping border, extending as far back as the crico-arytenoid joint.

Insertion.—The anterior aspect of the muscular process of the arytenoid cartilage, and the adjacent portion of the antero-external surface.

Nerve-supply.—The recurrent laryngeal nerve.

The fibres of the muscle are directed backwards and upwards.

Action.—To draw the muscular process of the arytenoid cartilage forwards and inwards, thereby swinging the vocal process or anterior angle inwards, the result of which is to narrow the rima glottidis. The two muscles, therefore, approximate and relax the true vocal cords, and they come into action in vocalization. When the posterior and lateral crico-arytenoid muscles act together they assist the arytenoid muscle in approximating the arytenoid carti-

lages, and so the rima glottidis is closed. The lateral crico-arytenoid muscle is covered externally by the ala of the thyroid cartilage and the upper fibres of the crico-thyroid muscle, and internally by the lateral expanded portion of the crico-thyroid membrane.

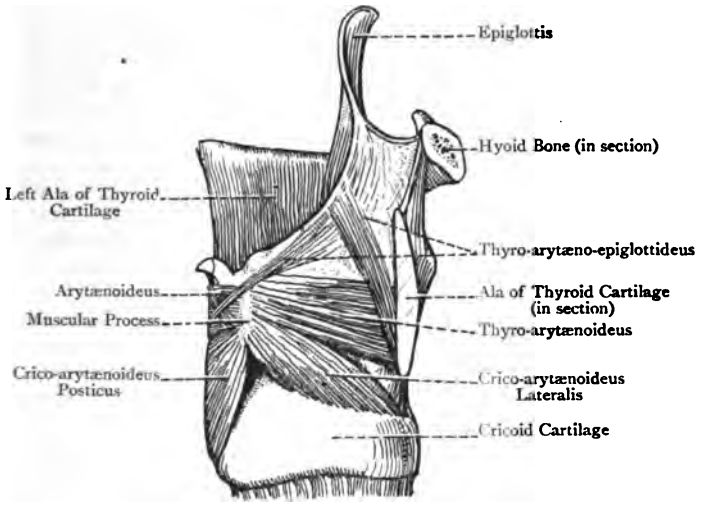


FIG. 518.—THE INTRINSIC MUSCLES OF THE LARYNX (LATERAL VIEW).

(The greater part of the Right Ala of the Thyroid Cartilage has been removed).

Thyro-arytenoid.—This muscle consists of two portions, external and internal.

External Portion—*Origin.*—(1) The lower half of the inner surface of the ala of the thyroid cartilage, and (2) the outer surface of the lateral portion of the crico-thyroid membrane.

Insertion.—The front of the muscular process and the adjacent part of the outer border of the arytenoid cartilage, a few of the fibres passing round the cartilage to become continuous with the arytænoideus. The uppermost fibres of this portion pass upwards and backwards to the aryteno-epiglottidean fold, and thence to the epiglottis, under the name of the **thyro-epiglottideus.**

Internal Portion—*Origin.*—(1) The receding angle of the thyroid cartilage, and (2) the cartilage of Luschka in the anterior part of the true vocal cord. According to Ludwig the deepest fibres of this portion, known as the **ary-vocalis,** spring from the anterior part of the true vocal cord.

Insertion.—The outer surface of the vocal process of the arytenoid cartilage, and the adjacent portion of the antero-external surface.

The fibres pass from before backwards, some of them having a slight inclination outwards, and the highest backwards.

Nerve-supply.—The recurrent laryngeal nerve.

Action.—(1) **Internal Portion.** To draw forwards the arytenoid cartilage, and the posterior part of the cricoid cartilage, swinging the latter in an upward and forward direction. The result of this action is to relax the true vocal cords by approximating the arytenoid cartilage to the thyroid cartilage. This portion of the muscle is, therefore, the antagonist of the crico-thyroid. It is to be borne in mind, however, that one factor in relaxation of the true vocal cords must of necessity be elastic recoil. The fibres representing the ary-vocalis muscle of Ludwig act, according to him, by rendering tense that part of the true vocal cord which is in front of them, and relaxing the part behind them.

(2) **External Portion.** In virtue of its insertion into the muscular process of the arytenoid cartilage this portion will draw forwards that process, the effect of which is to swing inwards the vocal process. The fibres known as the thyro-epiglottideus have been supposed to assist in depressing the epiglottis.

The outer portion of the muscle lies within the ala of the thyroid cartilage. Its lower border is contiguous to the lateral crico-arytenoid, and its upper fibres lie on the outer wall of the ventricle and saccule. The inner portion of the muscle is in close contact with the outer side of the true vocal cord.

Arytenoid.—This is a single muscle, the fibres of which extend transversely from the posterior surface of one arytenoid cartilage to the posterior surface of the other. Some of the fibres are continuous with those of the external portion of the thyro-arytenoid muscle.

Nerve-supply.—The recurrent laryngeal nerve.

Action.—To draw the arytenoid cartilages together, so as to approximate the true vocal cords, and even close the rima glottidis.

The muscle, clothed with mucous membrane, bounds the rima glottidis posteriorly, and its superficial surface supports the obliquely decussating arytæno-epiglottidei muscles.

Arytæno-epiglottideus.—Each of these muscles, which has the form of a narrow slip or band, arises from the back of the muscular process of the arytenoid cartilage.

Its direction is upwards and inwards, and it decussates with its fellow of the opposite side, thus X. Having reached the summit of the opposite arytenoid cartilage, a few of the fibres terminate upon it, but the majority enter the corresponding aryteno-epiglottidean fold. Being reinforced by a few fibres from the summit of the arytenoid cartilage, they pass forwards within the fold to be inserted into the side of the epiglottis, in conjunction with those fibres of the thyro-arytenoid which are known as the thyro-epiglottideus.

Nerve-supply.—The recurrent laryngeal nerve.

Action.—The two muscles, having the two arytenoid cartilages within their embrace, sweep them together with the aid of the arytenoid muscle, and narrow the superior aperture of the larynx in the manner of a sphincter muscle.

Compressor Sacculus Laryngis, or Hilton's Muscle.—This is the name given to a thin layer of muscular fibres on the inner side and upper end of the sacculus laryngis. The fibres are related superiorly to those of the arytæno-epiglottideus, which are contained within the aryteno-epiglottidean fold.

Summary of the Actions of the Laryngeal Muscles.—The intrinsic muscles of the larynx, by regulating the condition of the rima glottidis, contribute to vocalization, and modify the pitch of notes. In so doing they lengthen, so as to render tense, or shorten, so as to relax, the vocal cords; and they also bring the cords together, or draw them apart. In other words, the intrinsic muscles bring about *tension* and *parallelism* of the true vocal cords, or give rise to the opposite conditions, namely, *relaxation* and *divergence*.

Tension is effected by the crico-thyroid muscles, which swing the anterior part of the cricoid cartilage upwards and backwards towards the thyroid, the result being to increase the distance between the receding angle of the thyroid cartilage and the vocal processes of the arytenoid cartilages. In this manner the true vocal cords are stretched, and tension of them is produced.

Parallelism of the true vocal cords is effected by (1) the lateral crico-arytenoid muscles, and (2) the arytenoid muscle, the latter also producing narrowing of the glottis respiratoria (interarytenoid portion of glottis). The lateral crico-arytenoid muscles draw forwards the muscular processes of the arytenoid cartilages, the result of which is to swing inwards the vocal processes, and so produce parallelism. The arytenoid muscle draws the arytenoid cartilages together, and so narrows the glottis respiratoria, contributing at the same time to the condition of parallelism.

Relaxation of the true vocal cords is brought about by the thyro-arytenoid muscles, which draw the arytenoid cartilages, along with the posterior part of the cricoid cartilage, forwards. In this manner the distance between the receding angle of the thyroid cartilage and the arytenoid cartilages is diminished, and so relaxation of the true vocal cords is produced. They are at the same time shortened in virtue of their elastic recoil. The fibres of the thyro-arytenoid muscle, known as the ary-vocalis, act by rendering tense the part of the true vocal cord in front of them, and relaxing the part behind them (Ludwig).

Divergence of the true vocal cords and **opening of the rima glottidis** is effected by the posterior crico-arytenoid muscles, which draw the muscular processes of the arytenoid cartilages backwards and inwards, the result of which is to swing the vocal processes outwards. The actions of the intrinsic muscles may be tabulated thus:

Tension.	**Relaxation.**
Crico-thyroids.	Thyro-arytenoids.
Posterior crico-arytenoids.	Lateral crico-arytenoids.
Parallelism and Closure.	**Divergence and Opening.**
Lateral crico-arytenoids.	Posterior crico-arytenoids.
Arytenoid.	

Function of the Epiglottis.—Two views are held as regards the function of the epiglottis. (1) According to one view it is folded down, like a lid, over the superior aperture of the larynx. This lid-like action is brought about by (*a*) the pressure exerted by the base of the tongue, (*b*) the action of the arytæno-epiglottidei muscles, and (*c*) the action of the thyro-hyoid muscles, which elevate the thyroid cartilage. (2) According to Stuart and M'Cormick the epiglottis is never folded down like a lid. The superior aperture of the larynx, according to these authorities, is closed by the action of the arytenoid and thyro-arytenoid muscles. The arytenoid muscle approximates the arytenoid cartilages, and the thyro-arytenoid muscles draw them forwards, so as to bring them into contact with the epiglottis.

The sphincter-like action of the arytæno-epiglottidei muscles upon the superior aperture of the larynx must, however, be taken into account.

Primâ facie the lid-like action appears to be the most natural one. The results, however, of ulceration of the epiglottis, and consequent loss of function, would tend to support Stuart and M'Cormick's view.

Nerves.—The nerves of the larynx are the superior and inferior, or recurrent, laryngeal, both of which are branches of the pneumogastric.

The **superior laryngeal nerve** divides into two branches, external and internal. The **external branch** (external laryngeal nerve), which is comparatively small, supplies the **crico-thyroid muscle,** and also furnishes twigs to the inferior constrictor muscle of the pharynx. The **internal branch** (internal laryngeal nerve), which is *sensory*, passes beneath the posterior border of the thyro-hyoid muscle, and enters the larynx by piercing the thyro-hyoid membrane, in company with the superior laryngeal artery, above which it lies. In the interior of the larynx it breaks up into branches, some of which ascend to the aryteno-epiglottidean fold and posterior surface of the epiglottis, a few of them passing through the latter to reach its anterior surface. The other branches descend to supply the laryngeal mucous membrane, and one of them joins a twig from the inferior or recurrent laryngeal nerve.

The **inferior** or **recurrent laryngeal nerve** is the principal *motor* nerve of the larynx. It passes beneath the lower border of the inferior constrictor muscle, and ascends upon the cricoid cartilage, lying close behind the crico-thyroid joint. Here it divides into two branches, anterior and posterior. The *anterior branch* ascends under cover of the thyroid cartilage, and is distributed to the lateral crico-arytenoid, thyro-arytenoid, thyro-epiglottideus, and aryteno-epiglottideus muscles. The *posterior branch* passes upwards on the back of the cricoid cartilage beneath the posterior crico-arytenoid muscle, which it supplies, and then it goes on to end in the arytenoid muscle.

The recurrent laryngeal nerve furnishes some *sensory* branches

to the mucous membrane of the larynx below the rima glottidis, and it communicates with the internal branch of the superior laryngeal. The motor fibres of the external branch of the superior laryngeal and of the inferior laryngeal are derived from the bulbar portion of the spinal accessory nerve.

Summary of the Laryngeal Nerves.—The **superior laryngeal nerve,** through its **internal branch,** is *sensory,* and its **external branch** supplies the *crico-thyroid muscle,* and, in part, the inferior constrictor muscle of the pharynx.

The **inferior** or **recurrent laryngeal nerve** is chiefly *motor,* and it supplies the intrinsic muscles of the larynx, *with the single exception of the crico-thyroid muscle.*

Arteries.—The arteries of the larynx are the superior and the inferior laryngeal. The **superior laryngeal artery** is a branch of the superior thyroid. It accompanies the internal laryngeal nerve, below which it lies, and enters the larynx by piercing the thyro-hyoid membrane. The **inferior laryngeal artery** is a branch of the inferior thyroid, and it accompanies the inferior or recurrent laryngeal nerve.

Veins. — The **superior laryngeal vein** opens into the superior thyroid, and the **inferior laryngeal vein** into the inferior thyroid vein.

Lymphatics.—These are arranged in two sets—superior and inferior. The superior lymphatics come from the portion of the larynx above the rima glottidis. Having pierced the thyro-hyoid membrane, they pass to the upper group of deep cervical glands. The inferior lymphatics come from the portion of the larynx below the rima glottidis. Having pierced the crico-thyroid membrane, they pass to the lower group of deep cervical glands, having previously traversed the prelaryngeal glands.

In early life the larynx occupies a higher position than it does in the adult, its descent, which is gradual, being completed by puberty. Up to that period the projection known as the pomum Adami is not present. After puberty important changes take place. The cartilages increase in size, the pomum Adami assumes marked development, especially in the male, and the true vocal cords undergo increase in length. These various changes account for the modifications which the voice undergoes at and after puberty.

Development of the Larynx.—The larynx is developed from the upper part of a median diverticulum from the ventral aspect of the fore-gut, which diverticulum by its lower part gives rise to the trachea. The epiglottis, arytenoid cartilages, and aryteno-epiglottidean folds are developed from the *furcula,* which is an elevation, like a horseshoe, lying between the second, third, and fourth visceral arches of either side (see Fig. 491). The front part of the furcula gives origin to the epiglottis, the lateral parts to the aryteno-epiglottidean folds, and the back part (extremities of the horseshoe bend) to the arytenoid cartilages. The groove within the furcula represents the superior aperture of the larynx.

Prevertebral Muscles.

Rectus Capitis Anticus Major—*Origin.*—By four short tendons from the tubercles of the costal processes (anterior tubercles of the transverse processes) of the third, fourth, fifth, and sixth cervical vertebræ, where it coincides with the origin of the scalenus anticus.

Insertion.—The inferior surface of the basilar process of the occipital bone, from the pharyngeal tubercle obliquely outwards and forwards for about ½ inch.

Nerve-supply.—The cervical plexus.

The muscle is directed upwards and inwards.

Action.—To flex the head.

Relations—*Anterior.*—The upper part of the common carotid, and the internal carotid, arteries, the internal jugular vein, the pneumogastric and sympathetic nerves, and the pharynx. *Posterior.*—A part of the longus colli, and a large portion of the rectus capitis anticus minor.

Rectus Capitis Anticus Minor—*Origin.*—The front of the root of the costal process of the atlas.

Insertion.—The inferior surface of the basilar process of the occipital bone, between the foramen magnum and the outer part of the insertion of the rectus capitis anticus major.

Nerve-supply.—The anterior primary division of the first cervical nerve.

The muscle is directed upwards and slightly inwards.

Action.—To flex the head.

Rectus Capitis Lateralis—*Origin.*—The upper aspect of the extremity of the transverse process of the atlas at its front part.

Insertion.—The inferior surface of the jugular process of the occipital bone.

Nerve-supply.—The anterior primary division of the first cervical nerve.

The muscle passes vertically upwards.

Action.—To flex the head to one side.

Longus Colli.—This complex muscle consists of three parts—upper oblique, vertical, and lower oblique.

Upper Oblique Part—*Origin.*—The fronts of the tubercles of the costal processes (anterior tubercles of the transverse processes) of the third, fourth, fifth, and sixth cervical vertebræ.

Insertion.—The lateral aspect of the anterior tubercle of the atlas.

The fibres are directed upwards and inwards.

Vertical Part—*Origin.*—The fronts of the bodies of the last two cervical and first three thoracic vertebræ.

Insertion.—The fronts of the bodies of the second, third, and fourth cervical vertebræ.

Lower Oblique Part—*Origin.*—The fronts of the bodies of the first three thoracic vertebræ in common with the lower portion of the vertical part.

Insertion.—The fronts of the tubercles of the costal processes (anterior tubercles of the transverse processes) of the fifth and sixth cervical vertebræ.

Nerve-supply.—The anterior primary divisions of the adjacent spinal nerves.

Action.—To flex the cervical part of the vertebral column.

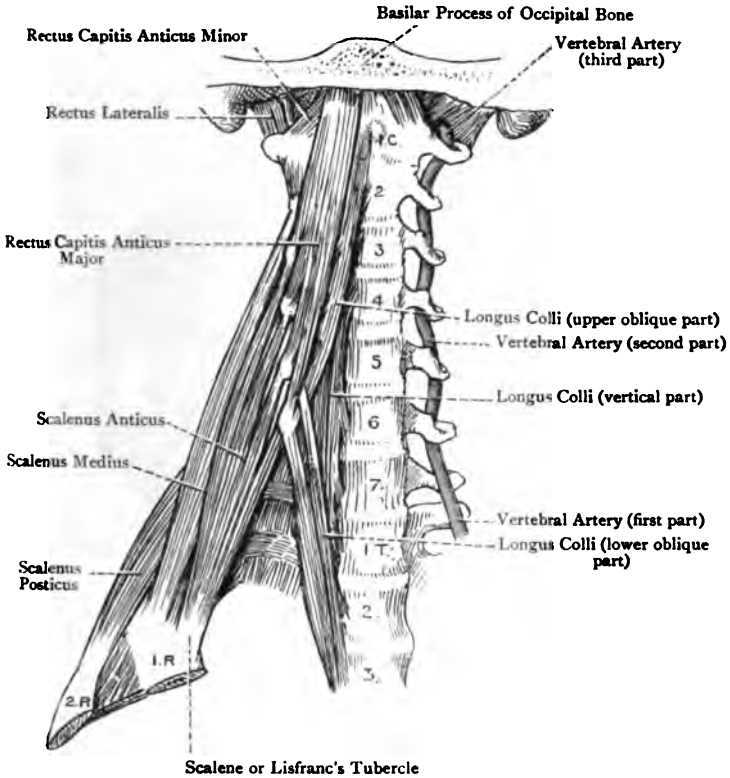


FIG. 519.—THE RIGHT PREVERTEBRAL MUSCLES.

(The Vertebral Artery is also shown).

Relations—*Anterior.*—The pharynx and œsophagus, the common and internal carotid arteries, and internal jugular vein ; the pneumogastric nerve, and the gangliated cord of the sympathetic ; the rectus capitis anticus major superiorly ; and the recurrent laryngeal nerve, inferior thyroid artery, and first part of the subclavian artery inferiorly. *Posterior.*—The bodies and discs of the adjacent vertebræ, and their transverse processes.

Petrous Part of the Internal Carotid Artery.—This part of the

internal carotid artery is contained within the carotid canal of the petrous part of the temporal bone. It is at first directed upwards, and then, describing a bend, it passes forwards and inwards to the foramen lacerum medium, where it enters upon the cavernous part of its course. The vessel is surrounded by small tympanic veins, and is accompanied by the ascending branch of the superior cervical ganglion of the sympathetic nerve. This branch breaks up into two divisions. One of these lies on the outer side of the artery, and gives rise to the carotid sympathetic plexus, whilst the other lies on the inner side of the artery, and goes on to form the cavernous sympathetic plexus.

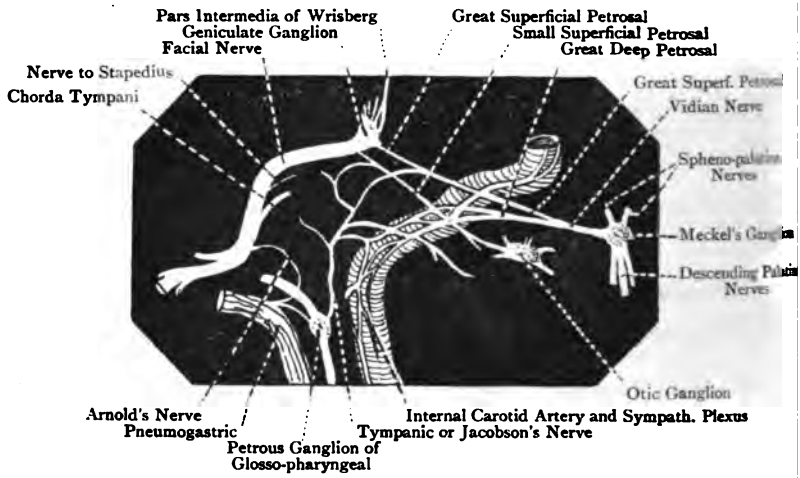


FIG. 520.—THE FACIAL NERVE IN THE AQUEDUCT OF FALLOPIUS, ETC. (HIRSCHFELD AND LEVEILLÉ).

As the artery ascends in the carotid canal it is situated in front of, and below, the tympanum and cochlea; as it bends it has the Eustachian tube on its anterior and outer side; and as it passes forwards and inwards it has the Gasserian ganglion above it, the partition between the two being for the most part membranous.

Branches.—The petrous part gives off a *tympanic branch* which enters the tympanum through the posterior wall of the carotid canal, and it may furnish a *petrosal branch* to accompany the great deep petrosal nerve.

For the cavernous part of the internal carotid artery, see p. 1003.

Petrous Part of the Facial Nerve.—This part of the nerve extends from the orifice of the meatus auditorius internus, on the posterior surface of the petrous part of the temporal bone, to the stylo-mastoid foramen, and it traverses (1) the meatus auditorius internus, and (2) the aqueduct of Fallopius.

Meatal Portion.—This portion of the nerve is directed outwards, and is accompanied by the pars intermedia of Wrisberg, the auditory nerve, and the internal auditory artery. It is placed upon the upper and anterior aspect of the auditory nerve, and the pars intermedia lies between the two, and here joins the facial nerve. At the deep end of the internal auditory meatus the facial nerve parts company with the auditory nerve, and enters the aqueduct of Fallopius.

Branches.—Two branches connect the facial nerve with the auditory nerve.

Portion in the Aqueduct of Fallopius.—The direction of this portion of the nerve corresponds to that of the aqueduct. It may conveniently be divided into three stages—first, second, and third. In the *first stage*, which is very short, the nerve passes horizontally outwards, between the cochlea and vestibule, to the inner wall of the tympanum, where it presents an enlargement, called the **geniculate ganglion.** It then describes a sharp bend, and in the *second stage* passes backwards, lying above the fenestra ovalis. Thereafter it describes another abrupt bend, and in the *third stage* descends behind the posterior wall of the tympanum to the stylo-mastoid foramen, by which it escapes from the aqueduct. The *hiatus Fallopii* leads from near the commencement of the aqueduct to the superior surface of the *pars petrosa*. As the aqueduct descends it communicates with the canal of the pyramid of the tympanum, and below this it presents another opening, called the *iter chordæ posterius*.

Branches.—These are as follows :

From Geniculate Ganglion:
- Great superficial petrosal (to Meckel's ganglion).
- Communicating branch to small superficial petrosal (to the otic ganglion).
- External superficial petrosal (to sympathetic plexus on middle meningeal artery).

Nerve to the stapedius muscle.
Chorda tympani nerve.
Communicating branch to the auricular branch (Arnold's nerve) of the pneumogastric.

The **great superficial petrosal nerve** arises from the geniculate ganglion and passes forwards through the hiatus Fallopii, by which it emerges from the aqueduct of Fallopius. It then courses inwards and forwards in a groove on the superior surface of the petrous part of the temporal bone, and passes beneath the Gasserian ganglion to the foramen lacerum medium. In the upper part of this foramen it joins the great deep petrosal nerve from the carotid plexus to form the Vidian nerve, which passes forwards through the Vidian canal into the spheno-maxillary fossa, and joins the back part of Meckel's ganglion. The great superficial petrosal nerve contains some motor fibres, but to a large extent it consists of sensory fibres. These represent peripheral branches of the unipolar cells of the geniculate ganglion, the central branches of which give rise to the pars intermedia of Wrisberg.

A **communicating branch** passes from the geniculate ganglion to the *small superficial petrosal nerve*, which latter represents the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal, after it has emerged from the tympanic plexus on the inner wall of the tympanum. Through means of the small superficial petrosal nerve this communicating branch is conducted to the otic ganglion.

The **external superficial petrosal nerve** (sometimes absent) emerges at a point just within the orifice of the hiatus Fallopii, and passes to the sympathetic plexus around the middle meningeal artery.

The **nerve to the stapedius muscle** arises from the facial nerve in the descending part of the aqueduct of Fallopius, opposite the pyramid of the tympanum. It enters a small canal in the pyramid, and so reaches the stapedius as that muscle lies within the canal.

The **chorda tympani nerve** arises from the facial in the descending part of the aqueduct of Fallopius, a little above the stylo-mastoid foramen. It passes upwards and forwards in a somewhat recurrent manner through a minute canal, called the *iter chordæ posterius*, by which it enters the tympanum. At first it is placed on the posterior wall of the tympanum, close to the posterior margin of the membrana tympani, and on a lower level than the pyramid. The nerve then passes forwards upon the membrana tympani, near its upper margin, lying between its mucous and fibrous layers, so as to be ensheathed by the mucous membrane. In this part of its course it passes over the inner aspect of the handle of the malleus. Having arrived at the inner end of the fissure of Glaser, it leaves the tympanum by passing through the *iter chordæ anterius* or *canal of Huguier*. It then enters the pterygo-maxillary region, and passes downwards and forwards under cover of the external pterygoid muscle, where it receives a communicating twig from the otic ganglion, and thereafter joins the lingual nerve at an acute angle, under cover of the external pterygoid muscle. The subsequent distribution of the nerve has been already described (see p. 1167).

The chorda tympani is principally composed of fibres which are the peripheral processes of the unipolar cells of the geniculate ganglion of the facial nerve. These represent the fibres which are distributed to the sides and dorsum of the tongue over its anterior two-thirds. They are, therefore, regarded as *gustatory*, or pertaining to taste, and functionally are afferent. They belong to the same group of fibres as compose the pars intermedia of Wrisberg, which represent the central processes of the unipolar cells of the geniculate ganglion of the facial nerve. In other words, the greater portion of the chorda tympani and the pars intermedia are to be regarded as one nerve, with the unipolar cells of the geniculate ganglion interpolated in their course in the form of cell-stations. The chorda tympani nerve, however, also contains purely facial fibres, which are the secretory fibres of the submaxillary and sublingual glands. The nerve is, therefore, a mixed nerve.

A **communicating branch** is given off from the facial nerve, just

above the stylo-mastoid foramen, which connects it with the auricular branch (Arnold's nerve) of the pneumogastric.

Pars Intermedia of Wrisberg.—The fibres of this small nerve arise from the unipolar cells of the geniculate ganglion of the facial, being the central processes of these cells, the peripheral processes representing the principal fibres of origin of the chorda tympani. The pars intermedia is at first closely incorporated with the facial nerve, and passes from the aqueduct of Fallopius into the internal auditory meatus. Here it separates from the facial nerve, and lies between it and the auditory nerve. After emerging through the orifice of the internal auditory meatus the pars intermedia passes to the lower border of the pons Varolii, where it enters the medulla oblongata, and terminates in the **fasciculus solitarius** and upper part of the glosso-pharyngeal nucleus.

The chorda tympani and the pars intermedia of Wrisberg, with the geniculate ganglion interpolated, may be regarded as representing the **afferent** or **sensory root** of the facial nerve.

Auditory Nerve in the Internal Auditory Meatus.—This nerve passes outwards in the internal auditory meatus in company with

FIG. 521.—SCHEME OF THE AUDITORY NERVE (FLOWER).

C.F. Communicating with Facial
C. Cochlear Nerve
V. Vestibular Nerve
S.S.C. To Superior Semicircular Canal
E.S.C. To External Semicircular Canal
U. To Utricle
S. To Saccule
P.S.C. To Posterior Semicircular Canal

the pars intermedia of Wrisberg, the facial nerve, and the internal auditory artery. The facial nerve is placed upon its upper and anterior aspect, and the pars intermedia lies between the two. Two branches connect the auditory nerve with the facial.

At the deep end of the meatus the auditory nerve breaks up into two divisions—an upper, called the vestibular nerve, and a lower, called the cochlear nerve. The **vestibular nerve** presents a ganglion, called the *ganglion of Scarpa*, which is situated at the deep end of the meatus, its bipolar cells giving origin to the vestibular fibres. Thereafter it breaks up into two parts, upper and lower. The **upper portion** furnishes branches which pass to the ampullæ of the superior and external semicircular canals, and to the utricle. These pass through the foramina of the *superior vestibular area* of the upper fossa of the *lamina cribrosa* at the deep end of the meatus. The **lower portion** supplies branches to the ampulla of the posterior semicircular canal and to the saccule. The former pass through the *foramen singulare* in the lower fossa of the lamina cribrosa, and the latter through the foramina of the *inferior vestibular area* of the lower fossa of the lamina cribrosa.

The branches of the **cochlear nerve** pass through the foramina of the *cochlear area* of the lower fossa of the lamina cribrosa.

Summary of the Petrosal Nerves.—There are three superficial petrosal nerves, namely, great, small, and external; and there are two deep petrosal nerves, namely, great and small.

Superficial Petrosal Nerves.—The *great superficial petrosal nerve* is a branch of the geniculate ganglion of the facial in the aqueduct of Fallopius. After emerging from that aqueduct through the hiatus Fallopii, it passes to the upper part of the foramen lacerum medium. Here it joins the great deep petrosal nerve to form the Vidian nerve, which passes forwards through the Vidian canal into the spheno-maxillary fossa, and joins the back part of Meckel's ganglion.

The *small superficial petrosal nerve* issues from the tympanic plexus on the inner wall of the tympanum, and represents the continuation of the tympanic branch (nerve of Jacobson) of the petrous ganglion of the glosso-pharyngeal nerve. As it traverses a canal in the petrous portion of the temporal bone it is joined by a small branch from the geniculate ganglion of the facial. Emerging from this canal through the accessory hiatus, it passes through the canaliculus innominatus, when present, or through the fissure between the *pars petrosa* and great wing of the sphenoid, or sometimes through the foramen ovale, into the zygomatic fossa, where it joins the otic ganglion, close below the foramen ovale.

The *external superficial petrosal nerve* (inconstant) is a branch of the geniculate ganglion of the facial. It emerges from the petrous part of the temporal bone through a small opening (inconstant) close to the hiatus Fallopii, and joins the sympathetic plexus on the middle meningeal artery.

Deep Petrosal Nerves.—The *great deep petrosal nerve* is a branch of the carotid plexus of the sympathetic. It joins the great superficial petrosal in the upper part of the foramen lacerum medium to form the Vidian nerve, which, as stated, passes through the Vidian canal into the spheno-maxillary fossa, and joins the back part of Meckel's ganglion.

The *small deep petrosal nerve* is a branch of the tympanic plexus. It passes forwards within the processus cochleariformis to the upper part of the foramen lacerum medium, where it joins the carotid plexus of the sympathetic, and the great deep petrosal nerve, or, it may be, the great superficial petrosal nerve. In this manner some of its fibres pass in the Vidian nerve to Meckel's ganglion.

The Articulations of the Atlas, Axis, and Occipital Bone.

Atlanto-axial Joints.—These are three in number, and they belong to the class **diarthrosis.** One is mesially placed, the articular surfaces being the atlantal facet on the anterior surface of the odontoid process of the axis and the odontoid facet on the posterior surface of the anterior arch of the atlas. This joint belongs to the subdivision **trochoides** or **pivot-joint.** The other two are placed one on either side, the articular surfaces of each being the inferior articular process of the atlas and the corresponding superior articular process of the axis. These two joints belong to the subdivision **arthrodia.**

Ligaments.—These are as follows: the transverse ligament, the capsular ligaments, and the accessory ligaments. Besides these there are the anterior and posterior atlanto-axial ligaments, which are not directly related to any of the joints.

The **transverse ligament** is usually spoken of as the *transverse ligament of the atlas.* It represents the transverse portion of the cruciform ligament, to be presently referred to, and it constitutes

a strong band, which is attached on either side to the tubercle on the inner aspect of the lateral mass of the atlas. It is arched backwards behind the odontoid process, and at the median line it is connected on its posterior aspect with the *crura* of the vertical portion of the cruciform ligament. Between the ligament and the odontoid process there is an extensive synovial membrane, which extends well over each lateral aspect of the process, so as to come very near another synovial membrane between the front of the process and the anterior arch of the atlas.

The **capsular ligaments** are loose sacs which surround the articulations between the inferior articular processes of the atlas and the superior articular processes of the axis.

The **accessory ligaments** are two in number—right and left. Each extends from the posterior surface of the body of the axis, close to

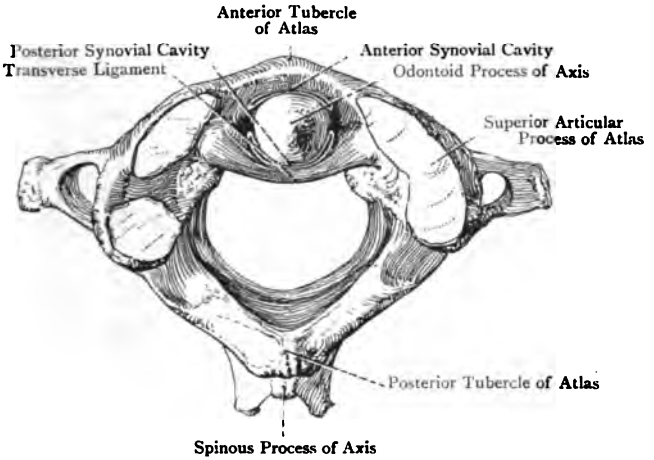


FIG. 522.—THE ARTICULATION BETWEEN THE ANTERIOR ARCH OF THE ATLAS AND THE ODONTOID PROCESS OF THE AXIS.

the root of the odontoid process, to the inner and posterior part of the lateral mass of the atlas. The direction of each ligament is upwards and outwards, and it is closely related superiorly to the capsular ligament, which it strengthens internally and posteriorly. The accessory ligaments are auxiliary in function to the check ligaments, and take part in limiting rotation of the atlas upon the axis.

The **anterior atlanto-axial ligament**, broad, thin, and membranous, is attached superiorly along the lower margin of the anterior arch of the atlas, and inferiorly to the anterior aspect of the body of the axis. It is serially continuous with the anterior common ligament of the bodies of the vertebræ, and its central portion is rendered thick by accessory fibres derived from the anterior common ligament.

The **posterior atlanto-axial ligament,** also broad, thin, and mem-

branous, extends from the under aspect of the posterior arch of the atlas to the upper borders and adjacent portions of the outer surfaces of the laminæ of the axis. It is serially continuous with, and represents, the ligamenta subflava of succeeding vertebræ.

Atlanto-occipital Joints.—These are two in number, right and left. They belong to the class **diarthrosis** and to the subdivision **condylarthrosis.** The articular surfaces are the condyles of the occipital bone and the superior articular processes of the atlas.

Ligaments.—These are as follows: the capsular ligaments and the anterior and posterior occipito-atlantal ligaments, the latter two being indirectly connected with the joints.

The **capsular ligaments** are loose sacs which directly surround the articulations. Their fibres are attached superiorly around the margins of the occipital condyles, and inferiorly to the lateral

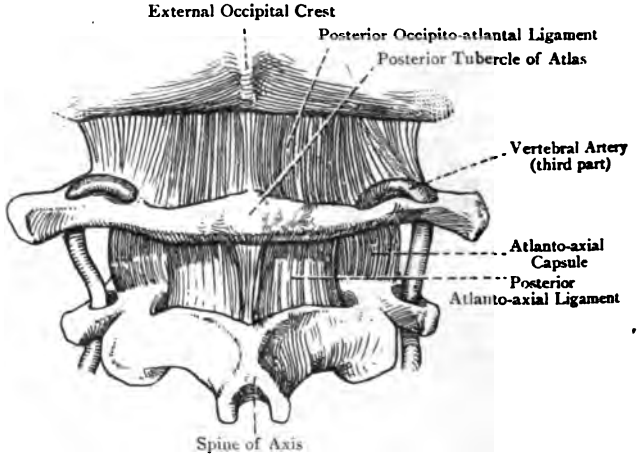


FIG. 523.—THE OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (SUPERFICIAL POSTERIOR VIEW).

masses of the atlas, external to the circumference of the superior articular processes.

The **anterior atlanto-occipital ligament,** thin and membranous, is attached inferiorly to the upper margin of the anterior arch of the atlas, and superiorly to the under surface of the basilar process of the occipital bone, close to the front part of the foramen magnum between the occipital condyles. In the median line it is rendered thick by the addition of a stout, round bundle of fibres, representing the *accessory ligament,* the fibres of which for the most part are attached below to the anterior tubercle of the atlas, but some of them are prolonged into the thickened anterior accessory part of the anterior atlanto-axial ligament.

The **posterior atlanto-occipital ligament,** broad, thin, and membranous, is attached inferiorly to the upper margin of the posterior arch of the atlas, except in the region of the vertebrarterial grooves,

and superiorly to the lower margin of the foramen magnum behind the occipital condyles. Over each vertebrarterial groove of the atlas this ligament forms an arch, beneath which the vertebral artery and suboccipital nerve pass.

Occipito-axial Ligaments.—These are as follows: the posterior occipito-axial ligament; the lateral odontoid, or check, ligaments; the middle odontoid, or suspensory, ligament; and the vertical portion of the cruciform ligament.

The **posterior occipito-axial ligament**, also called the *membrana tectoria*, is a broad membranous band, which is attached inferiorly to the posterior surface of the body of the axis, where it is continuous with the fibres of the posterior common ligament of the bodies of the vertebræ, and superiorly to the posterior part of the

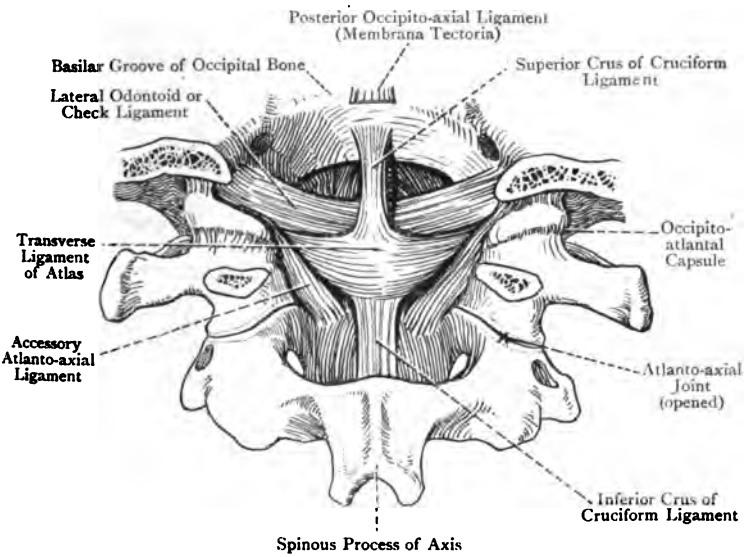


FIG. 524.—OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (POSTERIOR VIEW).

basilar groove of the occipital bone. It covers the odontoid process of the axis and the odontoid and cruciform ligaments, hence the name membrana tectoria.

The **vertical portion of the cruciform ligament** consists of two parts, upper and lower, which are spoken of as the superior crus and inferior crus. The *superior crus* extends from the posterior surface of the transverse ligament at the median line to the posterior part of the basilar groove of the occipital bone, between the anterior margin of the foramen magnum and the superior attachment of the membrana tectoria, under cover of which latter it lies. This crus, as it ascends, is in contact with the posterior surface of the head of the odontoid process. The *inferior crus* extends from the posterior surface of the transverse ligament at the median line

to the posterior surface of the body of the axis above the inferior attachment of the membrana tectoria.

The **transverse portion of the cruciform ligament** constitutes the transverse ligament of the atlas, already described.

The **middle odontoid** or **suspensory ligament** is a narrow round cord which is attached inferiorly to the ridge on the head of the odontoid process, and superiorly to the anterior margin of the foramen magnum in the median line.

The **lateral odontoid** or **alar ligaments,** also known as the **check ligaments,** form two very strong bands which are attached inferiorly to the sloping surfaces on the head of the odontoid process, and superiorly to an impression on the inner surface of each con-

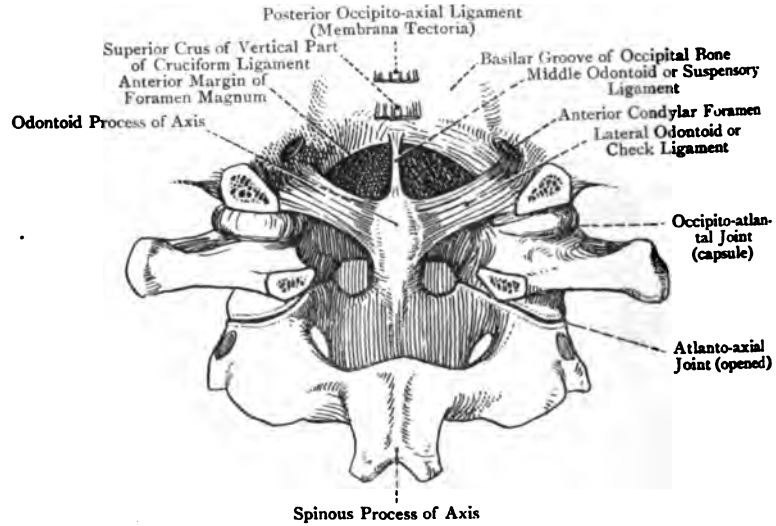

Posterior Occipito-axial Ligament
(Membrana Tectoria)
Superior Crus of Vertical Part of Cruciform Ligament
Anterior Margin of Foramen Magnum
Odontoid Process of Axis
Basilar Groove of Occipital Bone
Middle Odontoid or Suspensory Ligament
Anterior Condylar Foramen
Lateral Odontoid or Check Ligament
Occipito-atlantal Joint (capsule)
Atlanto-axial Joint (opened)
Spinous Process of Axis

FIG. 525.—THE OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (DEEP POSTERIOR VIEW).

dylar part of the occipital bone. The direction of each ligament is outwards and slightly upwards.

Movements—Atlanto-axial Joints.—The movements are of a *rotatory* kind, the altas, bearing the head, rotating on the axis, the odontoid process of which serves as a pivot. The extent of rotation is about 30 degrees, and it is limited by the lateral odontoid ligaments, aided slightly by the accessory atlanto-axial ligaments. The principal muscles concerned in rotation are the obliquus capitis inferior and rectus capitis posticus major of each side. **Atlanto-occipital Joints.**—The movements allowed at these joints are of a *nodding kind*, during which the head is depressed, so as to approximate the chin to the sternum, or raised to an erect position on the vertebral column, or even flexed in a backward direction. The principal muscles concerned in the nodding movements are the sterno-cleido-mastoids for forward depression, and the obliquus capitis superior, rectus capitis posticus minor, complexus, trachelo-mastoid, splenius capitis, and trapezius for the opposite movement.

THE NERVOUS SYSTEM

THE nervous system is arranged in two divisions, cerebro-spinal and sympathetic.

The **sympathetic nervous system** consists of (1) two gangliated cords, right and left, situated on either side of the vertebral column, and (2) three prevertebral plexuses, namely, the cardiac plexus, situated in the thorax; the epigastric or solar plexus; and the hypogastric plexus, the latter two being situated in the abdomen.

The **cerebro-spinal nervous system** or **axis** consists of the encephalon and the spinal cord, the former being situated within the cranial cavity, and the latter within the spinal canal. The continuity between these two divisions is established through the foramen magnum.

The cerebro-spinal axis is central in position, and is connected with the various parts of the body by the cranial and spinal nerves. It is composed of two kinds of nervous matter, white and grey. The **white matter** consists chiefly of nerve-fibres, and the **grey matter** consists of nerve-cells, with their axis-cylinder processes or axons and dendrites, the pervading supporting tissue in each case being called **neuroglia.** In the brain the white matter is disposed in the interior as the *medulla*, and the grey matter forms the exterior or *cortex*. In the spinal cord the white matter is disposed externally in the form of three columns on either side, whilst the grey matter is situated in the interior.

The cerebro-spinal axis is surrounded by three membranes, or *meninges*, which, from without inwards, are named the dura mater, arachnoid membrane, and pia mater.

The Spinal Cord.

Membranes of the Spinal Cord.—The membranes are three in number, namely, the dura mater, the arachnoid membrane, and the pia mater.

Dura Mater.—This is the most external covering of the cord.

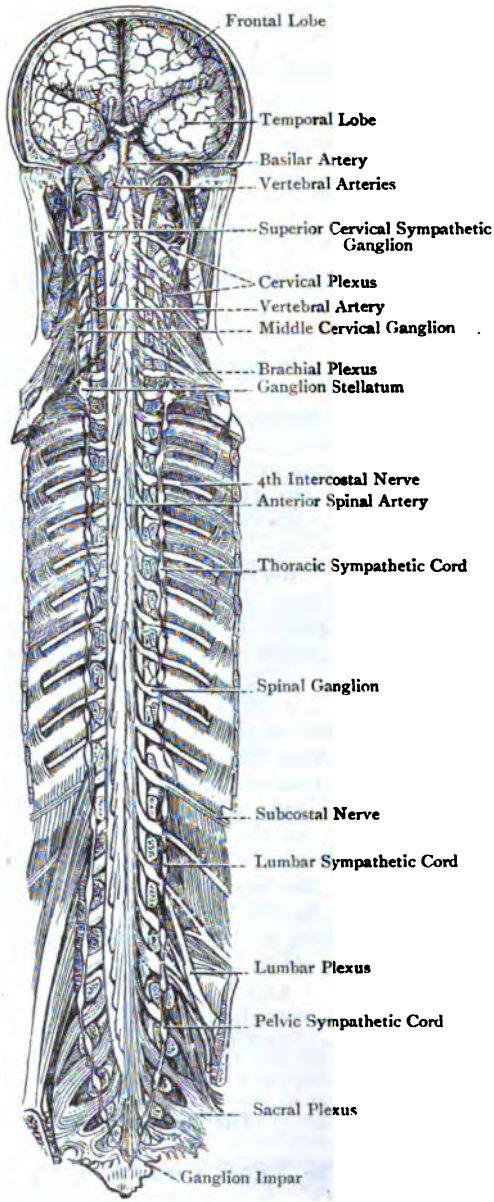


FIG. 526.—THE CEREBRO-SPINAL AND SYMPATHETIC SYSTEMS (ANTERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

It forms a firm fibrous tube, or *theca*, which extends from the margin of the foramen magnum to the back of the body of the second sacral segment. Superiorly it is continuous with the internal or sustentacular layer of the intracranial dura mater, the external layer of that membrane having blended with the occipital periosteum around the margin of the foramen magnum. The spinal dura mater, or theca, surrounds the spinal cord very loosely, and is separated from the walls of the spinal canal by an interval, known as the **epidural space,** which is occupied by venous plexuses and loose areolar tissue. The theca is prolonged, on either side, through the intervertebral foramina in the form of sheaths around the roots of the spinal nerves, which become continuous with their perineurium. It therefore presents on either side a series of openings, which are arranged in two parallel rows. The openings, constituting each pair, are placed side by side, but are distinct from each other, and they transmit the anterior and posterior roots of the spinal nerves.

The spinal dura mater differs from the intracranial dura mater in the following respects: (1) it is destitute of an outer or periosteal layer, and therefore does not form the periosteum of the spinal canal; (2) it does not send septa into the cord; and (3) it does not contain venous sinuses.

Blood-supply.—The arteries are derived from the spinal branches of the vertebral, deep cervical, intercostal, and lumbar vessels.

The lymph-spaces of the dura mater are in communication with those of the spinal nerves.

Nerve-supply.—The nerves are partly sympathetic and partly spinal.

Structure.—The dura mater consists of fibrous and elastic tissues, arranged as parallel longitudinal bundles. Its internal surface is covered by endothelial cells, which impart to it a smooth polished appearance.

Arachnoid Membrane.—This is a delicate membrane surrounding the spinal cord in the form of a tube which lies between the dura mater and pia mater. Superiorly it is continuous with the intracranial arachnoid, and it extends as low as the lower end of the theca. At either side it is prolonged before the processes of the ligamentum denticulatum. At the openings in the theca for the passage of the nerve-roots the endothelial cells covering the outer surface of the arachnoid become continuous with those which line the inner surface of the theca, and the remainder of the arachnoid blends with the perineurium of the nerves. Between the arachnoid and the dura mater there is a narrow interspace, called the **subdural space.** Between the arachnoid and the pia mater there is a wider interspace, called the **subarachnoid space.** At the back part of the spinal cord, in the median line, there is a membranous septum, incomplete above, called the *septum posticum*, which passes from the pia mater, as it crosses the posterior median fissure, to the contiguous part of the arachnoid. The ligamenta denticulata

also constitute imperfect septa, on either side, in connection with the subarachnoid space.

The **subdural space** is the narrow interspace between the dura mater and the arachnoid. It is prolonged outwards for a short distance along the nerve-roots, and is in communication with the lymph-spaces of the nerves. It contains a small amount of fluid which moistens the opposed endothelial surfaces.

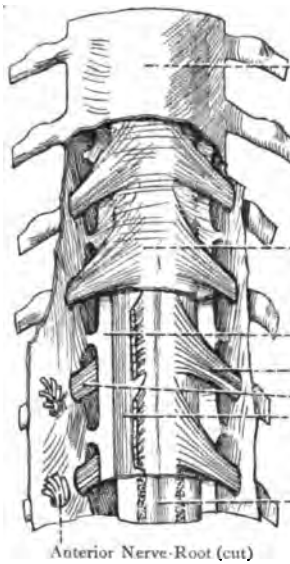


FIG. 527.—PORTION OF THE SPINAL CORD, SHOWING THE MEMBRANES, LIGAMENTA DENTICULATA, AND ROOTS OF THE SPINAL NERVES.

The **subarachnoid space** is the wide interspace between the arachnoid and the pia mater. It is crossed by delicate trabeculæ of connective tissue, which are arranged in a reticular manner, and the meshes of the reticulum contain cerebro-spinal fluid. It is continuous superiorly with the intracranial subarachnoid space (cisterna magna) and with the fourth ventricle of the brain through the foramen of Magendie and the foramina of Key and Retzius. On either side the subarachnoid space is incompletely divided into two compartments, anterior and posterior, by the corresponding ligamentum denticulatum; and posteriorly it is divided into two complete compartments, right and left, by the septum posticum, which, however, is incomplete above.

The subdural and subarachnoid spaces do not communicate with each other.

The nerves of the arachnoid are derived from the sympathetic system.

Structure of the Arachnoid Membrane.—The arachnoid consists of delicate bundles of fibrous tissue, which interlace with one another, and its external and internal surfaces are covered by endothelial cells.

Pia Mater.—This is the most internal covering of the spinal cord. It is a very vascular, fibrous membrane, and immediately invests

the external surface of the cord, to which it is closely adherent. Superiorly it is continuous with the intracranial pia mater, and inferiorly it extends, in association with the filum terminale, to the back of the first coccygeal segment. On either side it is prolonged, in the form of tubular sheaths, around the nerve-roots, and ultimately blends with their perineurium. Along the course of the anterior median fissure of the cord it sends a distinct process into that fissure, and along the course of the posterior median fissure the neuroglial septum, which occupies that fissure, is attached to it. From its deep surface several processes are given off which enter the cord at different points, and penetrate into it to variable distances. Its external surface is connected with the arachnoid by the reticular trabeculæ which traverse the subarachnoid space, and by the septum posticum. Upon the external surface of the pia mater there are three thickened bands, namely, the linea splendens, and the two ligamenta denticulata.

The **linea splendens** is a glistening band which is situated on the anterior surface in the median line, where it lies over the anterior median fissure. Inferiorly it is continued upon the conus medullaris, and into the filum terminale.

The **ligamenta denticulata** are situated one on either side of the spinal cord. Each ligamentum denticulatum is a lateral extension of the fibrous element of the pia mater, and it connects that membrane with the dura mater. Its attachment to the pia mater forms an uninterrupted band which is situated between the anterior and posterior nerve-roots, and extends from a point above the first cervical, or suboccipital, nerve to the commencement of the conus medullaris, beyond which its fibres are continued into the filum terminale. Its attachment to the dura mater takes the form of distinct, pointed processes, which are fixed to it in the intervals between successive pairs of nerve-roots. These processes are triangular, and they impart a characteristic denticulate, or serrated, appearance to the ligament externally. Each process is covered by the arachnoid membrane, which is prolonged outwards before it. The number of denticulations is about twenty-one. The highest

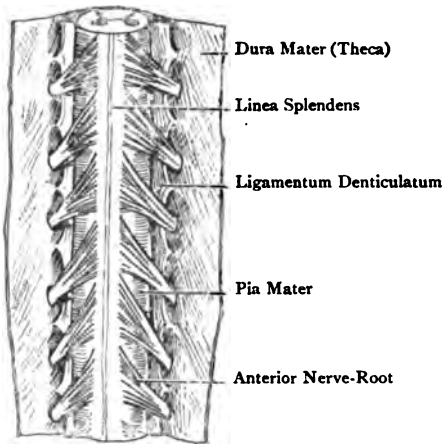


FIG. 528.—A PORTION OF THE SPINAL CORD (ANTERIOR VIEW).

(The Theca has been laid open, and the Arachnoid Membrane removed).

is situated above the suboccipital nerve, and the lowest is usually placed between the twelfth thoracic and first lumbar nerves. The ligamenta denticulata serve to support the spinal cord within its theca of dura mater. As stated, they divide the subarachnoid space on either side into two incomplete compartments, anterior and posterior, the former being traversed by the anterior nerve-roots, and the latter by the posterior nerve-roots.

Blood-supply.—The pia mater is extremely vascular, and derives its blood from the spinal branches of the vertebral, deep cervical, intercostal, and lumbar arteries.

Nerve-supply.—The nerves are derived from the sympathetic system.

Lymphatics.—The lymphatics pass to the deep cervical, posterior

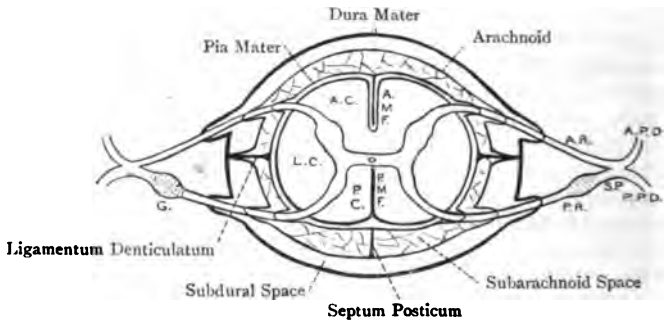


FIG. 529.—DIAGRAM OF A TRANSVERSE SECTION OF THE SPINAL CORD AND ITS MEMBRANES.

A.M.F. Anterior Median Fissure, with Process of Pia Mater
P.M.F. Posterior Median Fissure
A.C. Anterior Column
L.C. Lateral Column
P.C. Posterior Column
A.R. Anterior Nerve-Root
P.R. Posterior Nerve-Root
G. Spinal Ganglion
S.P. Spinal Nerve
A.P.D. Anterior Primary Division
P.P.D. Posterior Primary Division

intercostal, and lateral lumbar glands, which they reach through the intervertebral foramina.

Structure of the Pia Mater.—The pia mater consists of two layers, outer and inner. The *outer layer* consists of bundles of connective tissue, which are disposed for the most part longitudinally. The *inner layer* consists of areolar tissue, containing a great many bloodvessels, and its outer and inner surfaces are covered by endothelial cells. Lymphatic spaces occur at intervals between the two layers, and these spaces communicate with the subarachnoid space.

The spinal pia mater differs from the intracranial pia mater in being thicker and more adherent to the nervous substance. The greater thickness is due to the presence of the outer layer, the intracranial pia mater representing the inner layer of the spinal pia mater.

External Characters of the Spinal Cord.—The spinal cord, or *medulla spinalis*, which is somewhat cylindrical, is that division of the cerebro-spinal axis which is situated within the spinal canal. It extends from the lower margin of the foramen magnum in the occipital bone to about the level of the disc between the bodies of the first and second lumbar vertebræ, and it is about 18 inches in length. Superiorly it is continuous with the medulla oblongata, and inferiorly it terminates in a tapering portion, called the **conus medullaris.** From the lower end of this cone a slender, glistening thread, called the **filum terminale,** is continued downwards between the bundles of lumbar, sacral, and coccygeal nerves of either side, which constitute the cauda equina, to be attached to the back of the first coccygeal segment.

The spinal cord is of smaller dimensions than the spinal canal, and is therefore relieved from pressure during the ordinary movements of the vertebral column. It is surrounded by three membranes, already described, namely, the dura mater, the arachnoid membrane, and the pia mater, in this order from without inwards. Within its theca of dura mater the cord is suspended by means of the ligamenta denticulata, and the nerve-roots as they emerge through the openings in the theca.

The spinal cord varies in shape in different regions. In the *cervical region,* as seen in transverse section, it is transversely oval, and is slightly flattened from before backwards. In the *thoracic region* it is somewhat circular, but the transverse diameter exceeds the antero-posterior. In the *lumbar region* it is still more circular than in the thoracic region.

The cord presents two swellings, which are known as the cervical and lumbar enlargements, and which are associated with the numerous and large nerve-trunks destined for the upper and lower limbs. The **cervical enlargement** extends from near the commencement of the cord to the second thoracic vertebra, and its breadth is greatest opposite the sixth cervical vertebra. The **lumbar enlargement,** which is less conspicuous than the cervical, extends from the level of the tenth thoracic vertebra to the conus medullaris, and its breadth is greatest opposite the twelfth thoracic vertebra.

Filum Terminale.—This delicate glistening thread is also known as the *central ligament* of the cord. It lies in the median line between the lumbar, sacral, and coccygeal nerves of either side, which constitute the cauda equina, and it extends from the apex of the conus medullaris to the back of the first coccygeal segment. It is about 6 inches in length. As low as the back of the body of the second sacral segment it is situated within the theca, but at that level it pierces the theca, from which it receives an investment, and then passes to be attached to the back of the first coccygeal segment, where it blends with the periosteum. For some distance the filum terminale contains in its centre a prolongation of the central canal of the spinal cord, which is surrounded by some of the

grey matter. It is also composed of pia mater prolonged downwards from the conus medullaris, and reinforced by fibres derived from the lower portions of the ligamenta denticulata and linea splendens. Its lower part is purely fibrous.

FIG. 530. — THE TERMINAL PART OF THE SPINAL CORD, AND THE CAUDA EQUINA.

Cauda Equina.—This is situated within the lower part of the theca. It consists of the lumbar, sacral, and coccygeal nerves of each side, which are arranged in the form of a leash, and the filum terminale lies in the median line between the two nerve-leashes. On account of the high origins of the individual nerves, relatively to the positions of the intervertebral foramina through which they pass, the direction of the nerves is almost vertical until they reach the level of their respective foramina of exit.

Fissures of the Spinal Cord.—The spinal cord, which is somewhat flattened in front and behind, is incompletely divided into two symmetrical halves by two median fissures, anterior and posterior. The **anterior median fissure** extends into the cord for one-third of its thickness from before backwards, and it contains a fold of the pia mater. At the bottom of the fissure the transverse band of nerve-fibres, called the *anterior white commissure*, crosses between the two halves of the cord. The **posterior median fissure**, though so named, is not an actual fissure like the anterior, and does not contain a fold of the pia mater. It is just wide enough to contain a septum formed by neuroglia, and it extends into the cord for about half of its thickness from before backwards. The *posterior grey commissure* lies at the bottom of the fissure. The anterior median fissure is more distinct and wider than the posterior, but it is not so deep.

Each half of the cord presents a groove along the line of entrance of the fasciculi of the posterior nerve-roots, called the **postero-lateral sulcus,** but there is no similar groove along the line of emergence of the fasciculi of the anterior nerve-roots, these being spread over an area of some breadth. By means of the postero-lateral sulcus on the one hand and the area corresponding to the emergence of the fasciculi of the anterior nerve roots on the other, each half of the spinal cord is divided superficially into three columns, anterior, lateral, and posterior.

The **anterior column** is situated between the anterior median

fissure and the most external fasciculi of the anterior nerve-roots; the **lateral column** is the area between the most external fasciculi of the anterior nerve-roots and the postero-lateral sulcus; and the **posterior column** lies between the postero-lateral sulcus and the posterior median fissure. Practically the anterior column represents the region in front of the anterior nerve-roots, the lateral column the region between the anterior and posterior nerve-roots, and the posterior column the region behind the posterior nerve-roots. According to some authorities there are only two columns, namely, antero-lateral and posterior, the former extending from the anterior median fissure to the postero-lateral sulcus, and representing the combined anterior and lateral columns.

In the cervical region the surface of each posterior column presents a slight groove which is situated nearer the posterior median fissure than the postero-lateral sulcus. This groove is called the *posterior intermediate furrow*. It contains a septum of pia mater, and in this manner the posterior column of the cord is marked off into two tracts. The inner and smaller tract is called the **postero-median column,** or **column of Goll,** and the outer and larger is called the **postero-external column,** or **column of Burdach.** These two columns extend throughout the cord, but it is only above the level of the mid-thoracic region that they are separated from each other by a septum of pia mater, known as the *posterior intermediate septum.*

Origin of the Spinal Nerves. — There are thirty-one pairs of spinal nerves, which arise from the sides of the spinal cord. They are arranged in five groups, on either side, as follows: **cervical,** *eight* in number; **thoracic,** *twelve;* **lumbar,** *five;* **sacral,** *five;* and **coccygeal,** *one.* Each spinal nerve arises superficially from the cord by two roots, anterior and posterior, the posterior root being the larger of the two. The portion of the cord from which each pair of spinal nerves arise is spoken of as a *segment* of the cord. Each root is ensheathed by tubular prolongations of the coverings of the cord, namely, the pia mater, arachnoid, and dura mater, in this order from within outwards, and these sheaths ultimately blend with the perineurium. The roots are separated from each other by the lateral column of the cord and the ligamentum denticulatum, and they pass through separate openings in the theca of dura mater.

The **anterior roots** are composed of *efferent* or *motor fibres,* and their fasciculi emerge from the cord in an irregular manner, being spread over an area corresponding in breadth to the *caput* of the anterior cornu of the grey matter in the interior. The **posterior roots** are composed of *afferent* or *sensory fibres,* and their fasciculi enter the cord in a straight line along the course of the postero-lateral sulcus. Each posterior root presents an oval swelling, called the **spinal ganglion.** These ganglia are, for the most part, situated in the intervertebral foramina, and immediately beyond each ganglion the anterior and posterior roots unite to form

a **spinal nerve,** which is necessarily a *mixed* nerve, inasmuch as it is composed of afferent and efferent fibres.

Each spinal nerve breaks up into an *anterior* and a *posterior primary division.*

The upper cervical nerve-roots are short, and pass almost horizontally outwards. The succeeding nerve-roots, however, gradually increase in length, and incline downwards as they pass outwards. This downward inclination goes on increasing until it becomes almost vertical in the case of the lumbar, sacral, and

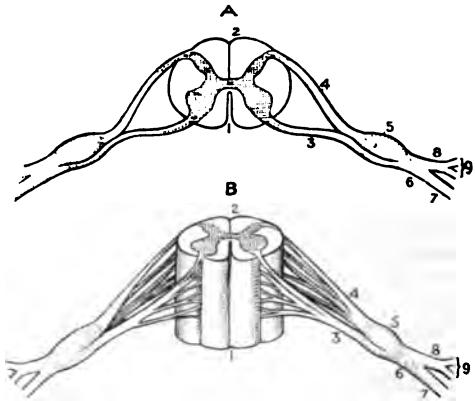


FIG. 531.—TWO SEGMENTS OF THE SPINAL CORD, SHOWING THE ATTACHMENTS OF THE ANTERIOR AND POSTERIOR NERVE-ROOTS, AND THE SPINAL GANGLIA.

A, Superior View; B, Anterior View.

1, 1. Anterior Median Fissure
2, 2. Posterior Median Fissure
3, 3. Anterior or Motor Nerve-Root
4, 4. Posterior or Sensory Nerve-Root
5, 5. Spinal Ganglion
6, 6. Spinal Nerve
7, 7. Anterior Primary Division
8, 8. Posterior Primary Division
9, 9. External and Internal Branches of Posterior Primary Division

coccygeal nerves, which constitute the cauda equina. From this disposition it follows that, in the majority of cases, the superficial origins of the spinal nerves are on a higher level than the intervertebral foramina through which they emerge from the spinal canal.

Relation of the Spines of Vertebræ to the Bodies and to the Origins of the Nerves.—In the case of the cervical and the eleventh and twelfth thoracic vertebræ the extremities of the spinous processes correspond to the lower margins of the bodies of the respective vertebræ. In the case of the thoracic vertebræ, from the first to the tenth inclusive, the extremity of each spinous process corresponds to the upper margin of the body immediately below. In the case of the lumbar vertebræ the extremity of each spinous process corresponds to the centre of the body of its own vertebra.

Each cervical spinous process is nearly opposite the lower fasciculi of the roots of the nerve below. The spinous process of the seventh cervical vertebra

(vertebra prominens) is opposite the roots of the first thoracic nerve. From the third to the tenth thoracic vertebræ the spinous processes correspond to the second root below. The eleventh thoracic spine corresponds to the first and second lumbar nerves. The twelfth thoracic spine corresponds to the third, fourth, and fifth lumbar nerves. The first lumbar spine corresponds to the first, second, and third sacral nerves. (Gowers, from an original investigation).

Mode of distinguishing the Anterior and Posterior Surfaces of the Spinal Cord.—These surfaces may be recognised by attending to the following points :

Anterior Surface.	Posterior Surface.
1. Linea splendens in median line.	1. Ganglion on each posterior nerve-root.
2. Anterior spinal artery in median line.	2. Fasciculi of posterior nerve-roots lie in a straight line, and enter through postero-lateral sulcus.
3. Fasciculi of anterior nerve-roots spread over a wide area.	3. Arterial anastomotic chain behind and in front of the posterior nerve-roots.

Internal Structure of the Spinal Cord.—The spinal cord, as seen in transverse section, consists of a central portion composed of grey matter, and an external portion composed of white matter.

Grey Matter.—This is arranged in the form of two irregular crescents, the concavities of which are directed outwards, and the convexities inwards, the latter being connected across the middle line by the grey commissure. The arrangement has been likened to the letter ⋈. The **grey commissure** lies at the bottom of the posterior median fissure, and presents about its centre the minute opening of the central canal of the cord. The part of the commissure in front of this canal is known as the *anterior grey commissure*, and the part behind as the *posterior grey commissure*. In front of the anterior grey commissure there is a transverse band of white matter, called the **anterior white commissure,** which lies at the bottom of the anterior median fissure. Each crescent of grey matter consists of two cornua, anterior and posterior, the former being in front of, and the latter behind, the grey commissure. The **anterior cornu** is broad and blunt, and it stops short of the surface of the cord, being separated from the surface by white matter which is traversed by the fasciculi of the anterior nerve-roots. The blunt extremity of the anterior cornu is called the *caput cornu*, and the portion adjoining the grey commissure, which is slightly constricted, is called the *cervix cornu*. The **posterior cornu** is, for the most part, long, narrow, and tapering, and its pointed extremity almost reaches the surface of the cord at the bottom of the postero-lateral sulcus. This pointed extremity is called the *apex cornu*, and it contains a translucent substance, known as the **substantia gelatinosa of Rolando.** The portion adjoining the grey

commissure, which is slightly constricted, is called the *cervix cornu*, and the portion contiguous to the cervix, which is slightly enlarged, is called the *caput cornu*.

About the centre of the concavity of each crescent the grey matter projects outwards into the lateral column in the form of processes arranged in a reticular manner and enclosing white matter. This network is called the **processus reticularis**, and it is most conspicuous in the cervical region. In the thoracic region, more particularly in its upper part, the grey matter of each crescent forms a triangular projection, which extends outwards for a short distance immediately in front of the processus reticularis, and adjacent to the junction of the anterior cornu with the grey com-

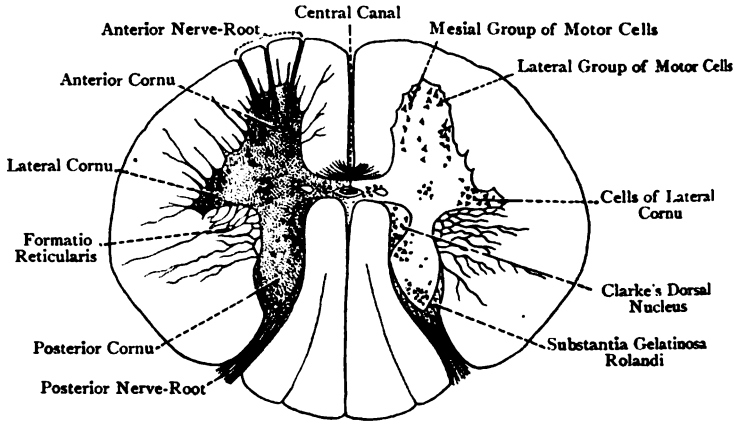


FIG. 532.—TRANSVERSE SECTION OF THE SPINAL CORD IN THE UPPER THORACIC REGION, SHOWING THE ARRANGEMENT OF THE GREY MATTER AND CELLS (SEMI-DIAGRAMMATIC) (AFTER POIRIER).

missure. This projection is variously known as the **lateral cornu**, the **intermedio-lateral tract of Lockhart Clarke**, or the **intermediate process of Gowers.** When followed into the lower cervical and into the lumbar regions it blends with the anterior cornu, the thickness of which it increases, but it is again present above the level of the fourth cervical vertebra.

The grey matter varies in amount in different parts of the cord. It is present in largest quantity in the lumbar enlargement, where the large nerve-trunks for the lower limbs arise, and next to this in the cervical enlargement, where the large nerve-trunks for the upper limbs arise.

The cornua of the crescents of grey matter vary in shape in different regions. In the cervical region the anterior cornua are short, broad, and blunt, and the posterior cornua are long, narrow, and pointed. In the thoracic region both cornua are narrow,

though the posterior is more so than the anterior. In the lumbar region both cornua are broad, though the anterior is more so than the posterior. These differences render sections of the spinal cord in the cervical, thoracic, and lumbar regions easily recognisable. As stated, the lateral cornu is also a characteristic of the cord in the thoracic region, more particularly in its upper part.

Central Canal.—This minute canal is situated about the centre of the grey commissure, and extends throughout the entire length of the spinal cord. Superiorly it is continued into the lower half of the medulla oblongata, and it opens into the lower part of the fourth ventricle at the calamus scriptorius. Inferiorly, near the apex of the conus medullaris, it becomes enlarged, and assumes the shape of an inverted T, thus ⊥. This enlargement is known as the **ventriculus terminalis of Krause.** From this point it is prolonged for some distance into the filum terminale, and it ends in a closed extremity. In the cervical and thoracic regions the central canal

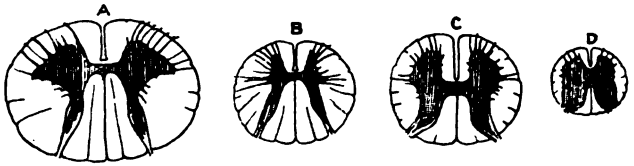


FIG. 533.—TRANSVERSE SECTIONS OF THE SPINAL CORD IN DIFFERENT REGIONS.

A, Cervical Region ; B, Mid-thoracic Region ; C, Lumbar Region ; D, Conus Medullaris.

is nearer the anterior surface of the cord than the posterior, but in the lumbar region it occupies the centre. In the conus medullaris it is near the posterior surface.

The canal is lined with ciliated columnar epithelium, the columnar cells being known as ependymal cells.

The central canal represents the lumen of the neural tube of epiblast from which the spinal cord is developed.

White Matter of the Spinal Cord.—The white matter forms the outer part of the cord, and is arranged in three columns, anterior, lateral, and posterior. The **anterior column** is situated between the anterior median fissure and the anterior cornu of grey matter, and extends as far as the most external fasciculi of the anterior nerve-roots. It therefore includes the superficial coating of the anterior cornu, where it is traversed, over an area of some breadth, by the scattered fasciculi of the anterior nerve-roots. The **lateral column** is situated between the anterior and posterior cornua of grey matter, in the concavity of the crescent. Its superficial limits are the most external fasciculi of the anterior nerve-roots and the fasciculi of the posterior nerve-roots at the postero-lateral sulcus.

The **posterior column** is situated between the posterior median fissure and the posterior cornu of grey matter, its superficial limit being the fasciculi of the posterior nerve-roots at the postero-lateral sulcus.

The white matter increases in quantity from below upwards, and septa of pia mater and neuroglia pass into it at various points.

Chief Distinguishing Characters of the Spinal Cord in Different Regions, as seen in Transverse Sections.

Cervical Region.	Thoracic Region.	Lumbar Region.
1. Transversely oval.	1. Approaching to circular.	1. Almost circular.
2. Anterior Cornu, short, broad, and blunt. Posterior Cornu, long, narrow, and tapering.	2. Anterior and Posterior Cornua both narrow, posterior more so than anterior.	2. Anterior and Posterior Cornua both broad, anterior more so than posterior.
3. Formatio Reticularis, well marked.	3. Formatio Reticularis, not very distinct.	3. Formatio Reticularis, absent.
4. Lateral Cornu, merged into anterior, except above fourth cervical vertebra.	4. Lateral Cornu, conspicuous, especially in upper part.	4. Lateral Cornu, merged into anterior.
5. White Matter, large in amount.	5. White Matter, less in amount, but large in proportion to Grey Matter.	5. White Matter, small in amount, and Grey Matter, large.
6. Central Canal, nearer the ventral than the dorsal surface.	6. Central Canal, nearer the ventral than the dorsal surface.	6. Central Canal, in the centre.
7. Postero-intermediate Sulcus and Septum of pia mater, well marked.	7. Postero-intermediate Sulcus, absent, but Septum of pia mater recognisable.	7. Postero-intermediate Sulcus and Septum of pia mater, absent.

Minute Structure of the Spinal Cord—Grey Matter.—The grey matter consists of nerve-cells, nerve-fibres, and neuroglia, and is very vascular.

The **nerve-cells** are present in great numbers, and are multipolar. Each cell sends off at various points several protoplasmic processes, one of which becomes the axis-cylinder of a nerve-fibre, and is called the *axis-cylinder process*, or *axon*. The other processes are known as the *protoplasmic processes of Deiters*, or *dendrites*, and, after successive branchings, they terminate in free extremities. There are no anastomoses between the dendrites of the same cell, nor between those of contiguous cells. A multipolar nerve-cell, with its axon and dendrites, constitutes a *neuron*. The multipolar

cells form longitudinal columns of various lengths, and, as seen in transverse sections of the cord, they are arranged in groups which occupy particular regions. These cell-columns or groups are three in number, namely, anterior or ventral, in the anterior cornu of grey matter; lateral, in the lateral cornu of grey matter; and posterior, constituting the posterior vesicular column of Lockhart Clarke, and being very conspicuous in the mesial portion of the cervix of the posterior grey cornu in the thoracic region. Besides these main columns or groups, other nerve-cells are present, which are scattered irregularly throughout the other portions of the grey matter.

The **anterior** or **ventral cell-column** is situated, as stated, in the anterior cornu of grey matter, and extends throughout the

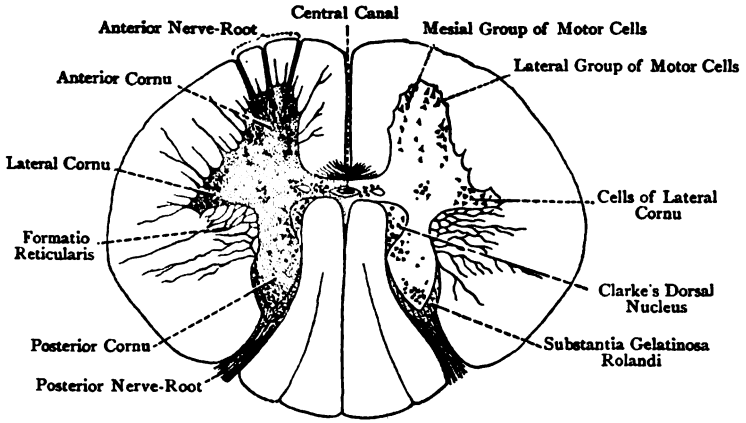


FIG. 534.—TRANSVERSE SECTION OF THE SPINAL CORD IN THE UPPER THORACIC REGION, SHOWING THE ARRANGEMENT OF THE GREY MATTER AND CELLS (SEMI-DIAGRAMMATIC) (AFTER POIRIER).

whole length of the spinal cord. Its cells are of large size and very conspicuous, and their axons, which are at first non-medullated, become medullated, and then constitute the fasciculi which emerge to form the anterior nerve-roots. These cells are therefore the sources from which the efferent or motor nerve-fibres proceed, and the ventral column is consequently spoken of as the **motor** or **ganglionic column.** The ventral or motor cells of this column are arranged in two groups, mesial and lateral. The *mesial group* occupies the mesial part of the anterior grey cornu, and the *lateral group* is situated in its outer part. In the cervical and lumbar enlargements of the cord the cells of the lateral group are very numerous, and are arranged in two sub-groups, ventro-lateral and dorso-lateral.

The **intermedio-lateral cell-column** is situated, as stated, in the

lateral cornu of grey matter, and is conspicuous only in the thoracic region, more particularly in the upper part. In other regions, though present, this group is not very distinct, and its cells are comparatively small.

The **posterior vesicular cell-column** is situated, as stated, in the mesial portion of the cervix of the posterior grey cornu, and is known as **Clarke's column.** Being chiefly confined to the thoracic region, it has been called the *dorsal nucleus of Stilling.* It extends from the eighth cervical nerve to the second lumbar, and its cells are of large size and very conspicuous. Their axons pass into the lateral column of white matter, where they form the direct cerebellar tract.

The cells of the grey matter are of three kinds, namely, the cells of Golgi, the root-cells, and the strand-cells. The *cells of Golgi* have short axons which do not leave the grey matter, but pass between adjacent cells, and so bring them into communication with one another. The *root-cells* have long axons, which leave the cord as efferent or motor fibres, as in the cells of the anterior grey cornu. The *strand-cells* also have long axons which form certain tracts or strands in the cord, as in Clarke's column.

The **nerve-fibres** are both medullated and non-medullated, and are present in every part of the grey matter, in which they form a close interlacement.

Grey Commissure.—This is composed of medullated nerve-fibres, which are of the nature of transverse commissural fibres extending between the cells of the posterior grey cornua. It contains the central canal of the cord, which is situated rather nearer the front than the back. The area immediately around the canal is free from nerve-fibres, and consists of a substance called the substantia gelatinosa centralis.

Varieties of Grey Matter.—There are two kinds of grey matter, namely, the substantia gelatinosa of Rolando, and the substantia gelatinosa centralis. The **substantia gelatinosa of Rolando,** as previously stated, is situated in the apex of the posterior grey cornu, and it contains many nerve-cells, but little neuroglia. The **substantia gelatinosa centralis,** as just stated, is situated around the central canal, and it consists of neuroglia and processes from the deep or outer ends of the columnar cells which line the central canal.

White Matter.—The white matter of the cord consists of nerve-fibres and neuroglia. The fibres are of the medullated variety, but each is destitute of a primitive sheath or neurilemma.

Anterior White Commissure.—This consists of medullated nerve-fibres. Some of them pass across transversely, but many are disposed obliquely, so that a decussation takes place. On either side they enter the anterior grey cornu and anterior column of white matter. The fibres are derived from the following sources: (1) the direct pyramidal tract; (2) some fibres of the anterior nerve-roots; and (3) fibres of the spino-thalamic tract, to be presently described.

Neuroglia of the Spinal Cord.—The neuroglia is the general supporting tissue of the grey and white matter, and has been so named from its apparent resemblance to glue, but it really consists of a horny substance, called *neuro-keratin*. It is composed of many cells, known as **glia-cells,** and a great number of delicate, branching fibres. The glia-cells are characterized by numerous branching processes, which constitute the **neuroglial fibres.** These fibres pervade the entire thickness of the cord, and interlace very freely with one another. On the surface of the cord the neuroglia forms a distinct layer beneath the pia mater, and from this layer processes are prolonged into the cord along with the septa of pia mater.

In early life the columnar cells which line the central canal send into the cord branching, filiform processes from their deep or outer ends.

Development.—The neuroglia is of epiblastic origin, and is developed from the spongioblasts of the neural tube, as are also the columnar cells (ependyma) which line the central canal.

Course of Nerve-fibres in the Cord — Anterior Nerve-roots.—The fibres of the anterior nerve-roots, having passed through the white matter of the anterior column, enter the anterior grey cornu. Thereafter some pass inwards, others outwards, whilst a third set pass backwards. The fibres which pass *inwards* end in one of two ways: (1) most of them become the chief processes or axons of the mesial group of cells in the anterior grey cornu of the same side; and (2) a few of them pass across in the anterior white commissure to the anterior grey cornu of the opposite side, where they become connected with its mesial group of cells. The fibres which pass *outwards* become the axons of the cells of the lateral group in the anterior grey cornu of the same side. The fibres which pass backwards enter the posterior grey cornu of the same side, and become connected with some of its cells. The fibres of the anterior nerve-roots are therefore principally confined to that side of the cord from which they emerge, and the *deep origin* of each fibre is a multipolar cell of the anterior grey cornu, of which cell it constitutes the chief process or axon.

Posterior Nerve-roots.—The fibres of the posterior nerve-roots have their origin in the unipolar cells of the spinal ganglia of the posterior nerve-roots. The single pole or process of each of these cells is T-shaped. One half of the horizontal limb of the T passes into the cord, and the other half passes outwards in the course of the nerve. Within the cord some of the fibres enter the caput cornu posterioris, others enter the postero-lateral column or column of Burdach, whilst those of a third set enter the tract of Lissauer. Each fibre divides into two branches, ascending and descending. The *descending branch*, after a short course, ends in an arborization around one of the cells of the posterior grey cornu. The chief process of that cell represents a new axon which passes forwards to the anterior grey cornu, where it ends in an

arborization around one of the anterior or motor cells. The *ascending branch* represents the principal part of the fibre. In its upward course it gives off collaterals, which are disposed in three ways. (1) Some terminate in arborizations around the cells of the anterior cornu, which they reach in part directly, and partly through the intervention of the cells of the posterior grey cornu

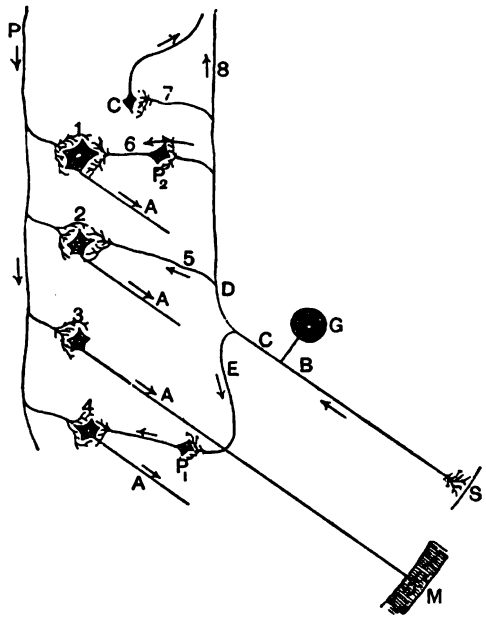


FIG. 535.—COURSE OF NERVE-FIBRES IN THE SPINAL CORD (FROM HALLIBURTON'S 'HANDBOOK OF PHYSIOLOGY' (AFTER SCHÄFER).

P. Pyramidal Tract
1, 2, 3, 4. Anterior Cornual Cells
A, A, A, A. Axons of Anterior Cornual Cells
M. Muscular Fibre
G. Unipolar Cell of a Spinal Ganglion, giving Origin to a Fibre of a Posterior Nerve-Root
B. Peripheral Branch of Fibre
S. Skin
C (lower C) Central Branch of Fibre, passing into the Spinal Cord
E. Descending Branch of Fibre in the Spinal Cord
D. Ascending Branch of Fibre in the Spinal Cord
P1, P2. Posterior Cornual Cells
C (upper C). Cell of Clarke's Column
5. Collateral, passing directly to arborize around an Anterior Cornual Cell (2)
6. Collateral, with an Intermediate Cell-Station in a Posterior Cornual Cell (P_2)
7. Collateral, arborizing around a Cell of Clarke's Column (upper C)
8. Continuation of Main Ascending Branch of Fibre

as intermediate cell-stations. (2) Others terminate in arborizations around the cells of Clarke's column in the thoracic region, and from these cells, as intermediate cell-stations, new axons pass into the direct cerebellar tract. (3) A few extend as high as the medulla oblongata, lying at first in Burdach's column, but being subsequently displaced into the column of Goll.

Spino-thalamic Fibres.—Some of the axons of the cells in the posterior grey cornu, around which certain fibres of the posterior nerve-roots have terminated in aborizations, enter the anterior white commissure. Having crossed to the opposite side, they enter the lateral column, and ascend to the optic thalamus of the side to which they have crossed. These fibres are known as the spino-thalamic fibres.

Spinal Ganglia.—These are situated on the *posterior* roots of the spinal nerves in the intervertebral foramina, and outside the theca, though invested by a prolongation from it. Each ganglion is oval, and consists of unipolar nerve-cells. The single pole of each cell divides into two processes, one of which is *centripetal* and forms part of the posterior nerve-root, whilst the other is *centrifugal* and passes into the spinal nerve. The pole and its inward and outward processes resemble the letter T. In early life the cells are bipolar.

The fibres of the posterior nerve-roots have their deep origins in the unipolar cells of the spinal ganglia, and they *grow into* the spinal cord. On the other hand, the fibres of the anterior nerve-roots have their deep origins within the spinal cord, where they arise as the axons of the multipolar nerve-cells of the anterior cornu of grey matter, and they *grow outwards*.

Conducting Tracts in the Spinal Cord—Posterior Column.—The recognised tracts of this column are as follows: (1) the column of Goll; (2) the column of Burdach, which contains the 'comma' tract; (3) the tract of Lissauer, which also invades the lateral column posteriorly; and (4) the ventral tract.

The **column of Goll** lies close to the posterior median fissure. The **column of Burdach** is placed externally, next the posterior grey cornu. These two columns are separated from each other, above the level of the mid-thoracic region, by the *posterior intermediate septum* of pia mater. They are long tracts, and derive their fibres from the posterior nerve-roots.

The **comma tract** is situated within the column of Burdach, in the thoracic region, and lies internal to the posterior grey cornu. The fibres of which it consists are probably the descending branches of the fibres of the posterior nerve-roots.

The **tract of Lissauer,** or *posterior marginal bundle,* is situated on the surface of the cord opposite the apex of the posterior grey cornu, and it invades the adjacent portions of the posterior and lateral columns. Its fibres are derived from the posterior nerve-roots, and they ascend to terminate in the substantia gelatinosa of Rolando.

The **ventral tract** is situated at the deep or ventral part of the posterior column, close to the corresponding half of the posterior grey commissure. It is probably composed of association or longitudinal commissural fibres.

Lateral Column.—The tracts of this column are (1) the direct cerebellar tract, (2) the tract of Gowers, (3) the crossed or lateral pyramidal tract, (4) the lateral ground-bundle, and (5) the lateral limiting area.

The **direct cerebellar tract** (*dorso-lateral ascending cerebellar tract*)

is an *ascending tract.* It consists of large fibres which are derived from the cells of the posterior vesicular column of Clarke in the mesial portion of the cervix of the posterior grey cornu. It commences in the lower part of the thoracic region, and, gradually increasing in size as it ascends, it passes through the lower part of the medulla oblongata, and finally is conducted to the cerebellum by the restiform body. It is situated in the posterior

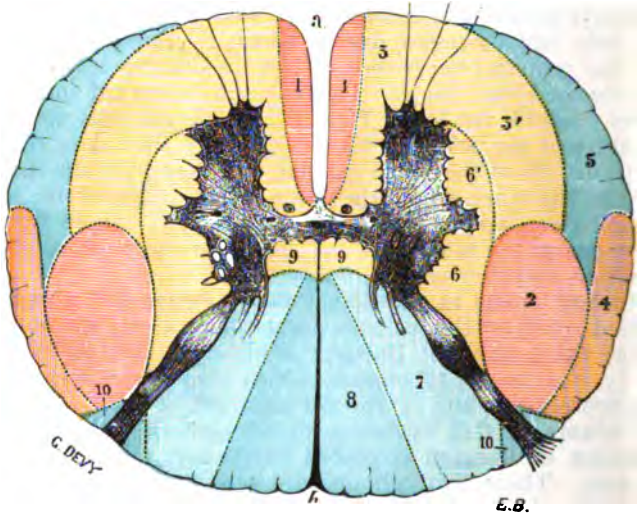


FIG. 536.—THE TRACTS OF THE SPINAL CORD (L. TESTUT'S 'ANATOMIE HUMAINE').

a. Anterior Median Fissure
b. Posterior Median Fissure
1. Direct Pyramidal Tract
2. Crossed Pyramidal Tract
3. Anterior Ground Bundle
3'. Lateral Ground Bundle
4. Direct Cerebellar Tract
5. Tract of Gowers
6, 6'. Lateral Limiting Zone
7. Tract of Burdach
8. Tract of Goll
9. Ventral Tract of Posterior Column
10. Tract of Lissauer

part of the lateral column, in front of the postero-lateral sulcus, where it lies on the surface of the cord, superficial to the crossed pyramidal tract.

The **tract of Gowers** (*antero-lateral ascending tract*, or *indirect cerebellar tract*) is situated in front of the direct cerebellar and crossed pyramidal tracts. It is broad behind, where it is in contact with the direct cerebellar tract and the crossed pyramidal tract, but anteriorly it tapers in the region of the emerging fasciculi of the anterior nerve-roots. The fibres of this tract are regarded as having their origin in the cells of the posterior grey cornu. It commences in the lower part of the thoracic region, and it can be traced through the medulla oblongata and pons Varolii into the

cerebellum through the superior cerebellar peduncle: hence the name of indirect cerebellar tract.

The **crossed** or **lateral pyramidal tract** is a *descending tract.* It is situated in the posterior part of the lateral column, immediately in front of the posterior grey cornu, being separated from the surface of the cord by the direct cerebellar tract, and having the tract of Gowers and the lateral ground-bundle in front of it. Superiorly it can be traced across the middle line into the opposite pyramid of the medulla oblongata, and thence through the pons Varolii, crus cerebri, and internal capsule of the corpus striatum to the pyramidal cells of the Rolandic region of the cerebral cortex. Inferiorly it can be traced to the lower end of the cord. As the tract descends fibres leave it at regular intervals and enter the anterior grey cornu, where they terminate in arborizations around the anterior or motor cells, from which the fibres of the anterior or motor nerve-roots arise.

The crossed pyramidal tract is the chief path by which *motor* impulses are conveyed from the Rolandic region of the cerebral cortex to the various segments of the spinal cord.

The **lateral ground-bundle** is situated in front of the crossed pyramidal tract, having the tract of Gowers on its outer side, and the lateral limiting area on its inner side. Anteriorly it is continuous with the anterior ground-bundle. It consists of association or longitudinal commissural fibres.

The **lateral limiting area** is situated between the crescent of grey matter internally and the crossed pyramidal tract and lateral ground-bundle externally. It is intimately related to the latter bundle, and, like it, is probably composed of association or longitudinal commissural fibres.

Anterior Column.—The tracts of this column are (1) the direct or anterior pyramidal tract, and (2) the anterior ground-bundle.

The **direct** or **anterior pyramidal tract,** or **column of Türck,** is a *descending tract.* It represents the narrow *mesial* portion of the anterior column, and lies close to the anterior median fissure. As a rule it ceases about the mid-thoracic region, but it may be traceable as low as the lumbar enlargement, or it may cease about the centre of the cervical enlargement. Superiorly it is continued into the medulla oblongata, where it forms the *outer* portion of the pyramid of the same side. Thereafter its fibres are traceable through the pons Varolii, crus cerebri, and internal capsule of the corpus striatum to the pyramidal cells of the Rolandic region of the cerebral cortex of the same side. As the fibres of this tract descend in the cord they cross at intervals, in the anterior white commissure, to the opposite anterior column, and enter the anterior grey cornu. Here, like the fibres of the crossed pyramidal tract, they terminate in arborizations around the anterior or motor cells, from which the fibres of the anterior or motor nerve-roots arise.

It is to be noted that, whilst the fibres of the crossed pyramidal

tract cross in the medulla oblongata, those of the direct pyramidal tract cross at intervals in the anterior white commissure of the spinal cord.

The **anterior ground-bundle** represents the greater part of the remainder of the anterior column. Like the lateral ground-bundle, with which it is continuous, it is composed, to a large extent, of fibres which act as association or longitudinal commissural fibres between segments of the cord at different levels.

In connection with the **antero-lateral column** there is a superficially-placed **antero-lateral descending cerebellar tract,** which is also known as the *anterior marginal bundle of Lowenthal.* It extends from the direct cerebellar tract to the direct pyramidal tract. Within the cord its nbres terminate in arborizations around the anterior or motor cells of the anterior grey cornu. Inferiorly it extends to the lumbar region of the cord. Superiorly its fibres become the axons of cells belonging to the nucleus of Deiters, and from these cells fibres proceed to the cortex of the cerebellum. These cells are to be regarded as intermediate cell-stations in the course of the fibres of the anterior marginal bundle of Lowenthal.

Summary of the White Matter of the Cord.—The white matter consists of nerve-fibres and neuroglia, and is arranged in three columns, anterior, lateral, and posterior, or, according to some authorities, two columns, antero-lateral and posterior. In the cervical and upper thoracic regions the posterior column is subdivided by the posterior intermediate furrow into the column of Goll, internal in position, and the column of Burdach, which is placed externally.

Tracts—Posterior Column.—(1) The column of Goll; (2) the column of Burdach (which contains the 'comma' tract); (3) the tract of Lissauer (posterior marginal bundle), which also invades the lateral column posteriorly; and (4) the ventral tract. **Lateral Column.**—(1) The direct cerebellar tract (dorso-lateral ascending cerebellar tract); (2) the tract of Gowers (antero-lateral ascending tract); (3) the crossed or lateral pyramidal tract; (4) the lateral ground-bundle; and (5) the lateral limiting area. **Anterior Column.**—(1) The direct or anterior pyramidal tract, or column of Türck; and (2) the anterior ground-bundle. **Antero-lateral Column.** — The anterior marginal bundle of Lowenthal (antero-lateral descending cerebellar tract).

The *descending tracts* are as follows: (1) the crossed or lateral pyramidal tract; (2) the direct or anterior pyramidal tract; (3) the 'comma' tract; and (4) the anterior marginal bundle of Lowenthal (antero-lateral descending cerebellar tract).

The *ascending tracts* are as follows: (1) the column of Goll; (2) the column of Burdach; (3) the direct cerebellar tract (dorso-lateral ascending cerebellar tract); (4) the antero-lateral ascending (cerebellar) tract of Gowers; and (5) the tract of Lissauer, or posterior marginal bundle.

The principal *longitudinal commissural fibres* are met with in (1) the anterior ground-bundle, (2) the lateral ground-bundle, (3) the lateral limiting area, and (4) the ventral tract.

Arteries of the Spinal Canal and Spinal Cord—Arteries of the Spinal Canal.—These vessels enter the spinal canal through the intervertebral and sacral foramina. In the cervical region they are branches of the vertebral and deep cervical arteries; in the thoracic and lumbar regions they are derived from the dorsal

branches of the intercostal and lumbar arteries; and in the sacral region they come from the lateral sacral arteries. Within the spinal canal each **spinal artery** divides into three branches, namely, neural or central, and two parietal, anterior and posterior. The *neural* or *central branch* pierces the theca of the spinal cord. It supplies the coverings of the cord and the nerve-roots, and it anastomoses with the anterior and posterior spinal arteries on the cord. The neural branch is sometimes spoken of as the *lateral spinal artery*. The *anterior parietal branch* of each side passes to the back of the body of a vertebra, near the pedicle, and there it divides into two branches, ascending and descending. These anastomose with the adjacent offsets of the contiguous anterior parietal branches, and in this manner a **lateral longitudinal anastomotic chain** is formed, which communicates, at frequent intervals, with its fellow of the opposite side by transverse branches. From these transverse branches ascending and descending offsets are given off, which anastomose with adjacent offsets of contiguous transverse branches, and in this manner a **median longitudinal anastomotic chain** is formed on the backs of the bodies of the vertebræ. There are thus three longitudinal chains on the posterior surfaces of the bodies of the vertebræ, one being median and two lateral. From these chains branches are furnished to the bodies of the vertebræ and their ligaments. The *posterior parietal branch* of each side passes to the front of a lamina, where it acts in a manner similar to the anterior parietal branch. Two **posterior longitudinal anastomotic chains** are thus constructed in front of the laminæ, one at either side, which communicate at frequent intervals by transverse branches, and from these sources offsets are furnished to the laminæ and ligamenta subflava.

Arteries of the Spinal Cord.—These are: (1) the anterior spinal artery; (2) the posterior spinal arteries, right and left; and (3) the lateral spinal arteries, right and left (neural or central branches just described in connection with the spinal canal).

The **anterior spinal artery** is formed by the union of the *anterior spinal branches*, right and left, of the vertebral arteries. It descends along the front of the cord in the median line, and is reinforced at regular intervals by the lateral spinal arteries. In this manner an anterior longitudinal anastomotic chain is formed, which descends for some distance on the filum terminale.

The **posterior spinal arteries** are two in number, right and left, and each is a branch of the corresponding vertebral artery. Each vessel descends on the side of the cord in two branches, one being in front of, and the other behind, the posterior nerve-roots. These are reinforced by branches from the lateral spinal arteries, and the lateral longitudinal anastomotic chains, formed in this manner, extend over the entire length of the cord. There are thus five longitudinal anastomotic arterial chains in connection with the cord, namely, one anterior, and two lateral on each side, of which one is in front of, and the other behind, the posterior nerve-roots.

From these chains branches are freely given to the pia mater, and through it to the cord.

Veins of the Spinal Column and Spinal Cord — Veins of the Spinal Column.—These veins, which form plexuses, are disposed in five sets, namely, (1) dorsal, (2) veins of the vertebral bodies, (3) anterior intraspinal, (4) posterior intraspinal, and (5) anterior extraspinal.

The **dorsal spinous venous plexus** is situated deeply upon the superficial surface of the neural arches of the vertebræ, under cover of the multifidus spinæ muscle. It receives its tributaries from the integument and muscles of the back, and it communicates with the posterior longitudinal intraspinal plexus by branches which pierce the ligamenta subflava. In the neck the blood is conveyed away from the plexus by veins which open into the vertebral venous plexus around the vertebral artery of each side; in the thoracic region by veins which join the dorsal branches of the intercostal veins; and in the lumbar region by veins which join the dorsal branches of the lumbar veins.

The **veins of the bodies of the vertebræ** (*venæ basis vertebræ*) are contained within the cancellated tissue of the vertebral bodies. They communicate in front with the anterior extraspinal veins, and posteriorly they terminate in two venous trunks which, emerging through the two foramina on the posterior surface of each vertebral body, open into the transverse communicating branch between the two anterior longitudinal intraspinal veins.

The **anterior longitudinal intraspinal veins** form two anastomotic chains, which are situated on the posterior surfaces of the bodies of the vertebræ, one on either side. They communicate with each other opposite the centre of each body by transverse branches which receive the terminal trunks of the venæ basis vertebræ. These transverse branches pass between the posterior common ligament and the bodies of the vertebræ. Superiorly the anterior intraspinal veins communicate with the vertebral and the transverse or basilar plexuses of veins, and laterally an offset passes outwards through each intervertebral foramen, which, with that of the posterior intraspinal vein, forms a plexus around the adjacent spinal nerve.

The **posterior longitudinal intraspinal veins** are situated in front of the laminæ, one on either side, and they are connected at frequent intervals by transverse branches. They communicate with the dorsal spinous venous plexus by branches which pierce the ligamenta subflava. Superiorly they communicate with the marginal sinuses, on either side of the foramen magnum and vermiform fossa, which by their union form the occipital sinus. With the marginal sinuses and the anterior intraspinal veins they form a venous ring at the foramen magnum. Laterally each vein sends outwards through the corresponding intervertebral foramen an offset, which, with that of the anterior intraspinal vein, forms a plexus around the adjacent spinal nerve.

The anterior and posterior intraspinal veins are situated between the theca of dura mater and the wall of the spinal canal.

The **anterior extraspinal veins** form a plexus along the anterior aspect of the bodies of the vertebræ, which is most copious in the neck. On either side it communicates with the vertebral plexus, around the vertebral artery in the neck, the intercostal veins in the thoracic region, and the lumbar veins in the lumbar region. It is also connected with the venæ basis vertebræ.

Veins of the Spinal Cord.—These vessels lie within the substance of the pia mater, and are disposed as venous chains, one being in front, one behind, and two on either side. The anterior vessel lies over the anterior median fissure beneath the anterior spinal artery;

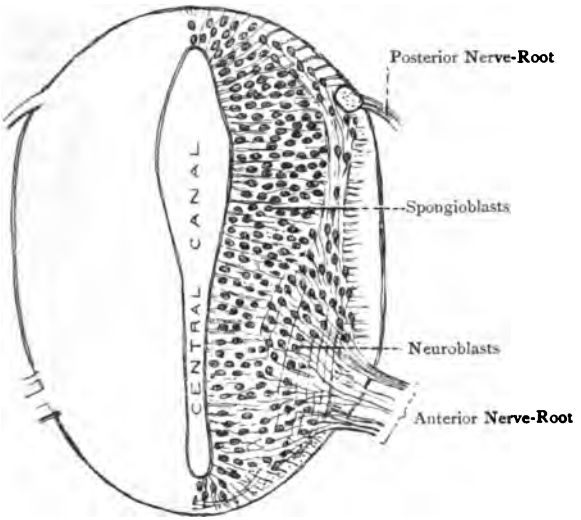


FIG. 537.—SECTION OF THE SPINAL CORD OF A HUMAN EMBRYO OF FOUR WEEKS (HIS).

the posterior vessel is also mesially placed; and the two lateral vessels are situated one in front of, and the other behind, the posterior nerve-roots. Besides these principal chains the veins form a plexus on the surface of the cord. Laterally branches emerge through the intervertebral foramina, which, along with the offsets of the anterior and posterior intraspinal veins, form plexuses around the spinal nerves. From these plexuses the blood is conveyed on either side into the vertebral plexus and deep cervical vein in the neck, and into the intercostal and lumbar veins in the corresponding regions.

Lymphatics.—There are no lymphatic vessels in the spinal cord. Their place is taken by spaces in the outer coat of the arteries,

called **perivascular spaces,** which are in communication with the subarachnoid space.

Development of the Spinal Cord.—The spinal cord is developed from the spinal portion of the neural tube of epiblast. The epiblast of the neural tube is composed of closely-set, columnar epithelial cells, called **spongioblasts,** the inner free ends of which line the tube, and are ultimately provided with cilia. These cells constitute at first the entire wall of the neural tube. As the wall increases in thickness they become elongated, and ramifications are formed between adjacent cells, thus giving rise to a reticulum, called the *myelospongium.*

Other cells, round in outline, called **germinal cells,** soon make their appearance between the inner or free ends of the spongioblasts.

Between the layer of germinal cells and the periphery of the spinal cord a third group of cells appears, these cells being called **neuroblasts.** The outer ends of these cells are prolonged into processes which are primitive fibres of the anterior roots of the spinal nerves.

The wall of the spinal portion of the neural tube thus comes to be formed of three sets of cells, namely, spongioblasts, germinal cells, and neuroblasts.

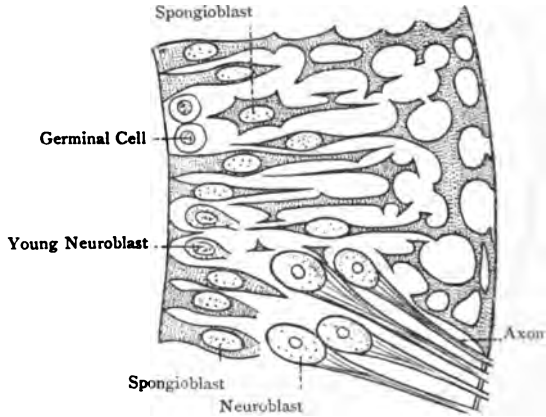


FIG. 538.—THE CELLS OF THE SPINAL CORD OF THE HUMAN EMBRYO (L. TESTUT'S 'ANATOMIE HUMAINE'; AFTER HIS).

The neuroblasts represent the central portion or grey matter of the primitive cord. The external portion or periphery is composed of the outer ends of the spongioblasts, a portion of the myeloplasm, and the processes (primitive nerve-fibres) which are prolonged from the outer ends of the neuroblasts, and these represent the white matter of the primitive cord. Subsequently longitudinal nerve-fibres make their appearance, and give rise to the white columns of the cord.

The cornua of grey matter are developed from the central collections of neuroblasts. As the anterior grey cornua grow outwards, and as the anterior columns of white matter become enlarged, the anterior median fissure makes its appearance.

The neuroglia of the cord and the lining epithelium of the central canal are developed from the spongioblasts, and are therefore of epiblastic origin.

The central canal of the cord is the persistent remains of the lumen of the neural tube.

The membranes of the cord are of mesoblastic origin.

THE ENCEPHALON.

The encephalon is the part of the cerebro-spinal axis which is contained within the cranial cavity. It is composed of the medulla oblongata, pons Varolii, cerebellum, and cerebrum. Originally it consists of three hollow vesicles, namely, the anterior cerebral vesicle, which represents the prosencephalon or fore-brain; the middle cerebral vesicle, representing the mesencephalon or mid-brain; and the posterior cerebral vesicle, corresponding to the rhombencephalon or hind-brain.

Encephalon = { **Prosencephalon** or Fore-brain. / **Mesencephalon** or Mid-brain. / **Rhombencephalon** or Hind-brain.

The subdivisions of the prosencephalon are the telencephalon and the thalamencephalon or diencephalon; the mesencephalon remains undivided; and the subdivisions of the rhombencephalon are the metencephalon and the myelencephalon.

Prosencephalon = { **Telencephalon.** / **Thalamencephalon** or **Diencephalon.**

Mesencephalon = **Mesencephalon.**

Rhombencephalon = { **Metencephalon.** / **Myelencephalon.**

The various parts of the encephalon which are developed from these subdivisions will be made evident from the following table:

Telencephalon = { Cerebral Hemispheres. / Lateral Ventricles. / Anterior part of Third Ventricle. / Foramina of Monro. / Olfactory Lobes.

Thalamencephalon or **Diencephalon** = { Posterior Part of Third Ventricle. / Optic Thalami. / Pineal Body. / Interpeduncular Structures. / Pituitary Body. / Optic Nerve and Retina.

Mesencephalon = { Corpora Quadrigemina. / Crura cerebri. / Aqueduct of Sylvius.

Metencephalon = { Cerebellum. / Pons Varolii. / Pontine Part of the Fourth Ventricle.

Myelencephalon = { Medulla Oblongata or Bulb. / Bulbar Part of Fourth Ventricle.

General Description of the Base and Superior Surface of the Encephalon.

The inferior aspect of the encephalon is known as the **base.** In the following general description of the parts which it presents the order pursued is, as nearly as possible, from behind forwards and upwards.

The **medulla oblongata,** or **bulb,** lies on the under aspect of the cerebellum, in the median line, occupying the vallecula which separates the two cerebellar hemispheres. The surface exposed is the ventral surface, which presents (1) the anterior median fissure, crossed at its lower part by the decussation of the pyramids; (2) the pyramid, on either side of this fissure; and (3) the olivary body, external to each pyramid.

The **hemispheres of the cerebellum** lie one on either side of the medulla oblongata, and they conceal from view the posterior parts of the cerebral hemispheres, and the posterior part of the great longitudinal fissure. They are characterized by the laminated arrangement of their nervous matter, the laminæ being curved and separated from each other by fissures. Posteriorly the hemispheres are separated from each other by the posterior notch. When the medulla oblongata is raised, and the cerebellar hemispheres slightly separated from each other, the **vallecula** is fully exposed, and the **inferior vermis** is seen lying deeply in it, with the *sulcus vallecula* on either side of it.

The **pons Varolii** forms a prominent elevation above the medulla oblongata, the surface exposed being the ventral surface. In the median line this surface presents a longitudinal groove, which is occupied by the basilar artery. On either side of the pons the **middle peduncle of the cerebellum** is seen, passing outwards and backwards into the cerebellar hemisphere.

The **temporal lobes of the cerebrum** are situated in front of the cerebellar hemispheres, and are conspicuous by their prominence. Each terminates anteriorly in a projecting extremity, called the **temporal pole.**

The **stem** of the **fissure of Sylvius** lies immediately in front of the temporal lobe, and is occupied by the middle cerebral artery. At the inner end of the stem of the fissure of Sylvius is the depression known as the *vallecula Sylvii.*

The **frontal lobe of the cerebrum** lies in front of the stem of the fissure of Sylvius. The exposed part is the orbital surface, which is separated from its fellow of the opposite side by the great longitudinal fissure. Each orbital surface presents a straight fissure, called the **olfactory sulcus,** which is situated near the great longitudinal fissure, and is parallel to it. This sulcus is occupied by the **olfactory tract** and **olfactory bulb.**

The **crura cerebri,** right and left, appear at the upper border of the pons Varolii, and soon diverge from each other as they pass forwards and upwards to sink into the cerebral hemispheres.

The **optic tract** of each side winds round the outer and ventral aspects of the corresponding crus cerebri. Its course is forwards and inwards towards its fellow of the opposite side.

The **optic commissure,** or **chiasma,** connects the two optic tracts after their convergence.

The **optic nerves,** right and left, leave the front of the commissure, and pass forwards and outwards to the optic foramina.

The **interpeduncular space** is situated in front of, and above, the pons Varolii. It is somewhat diamond-shaped, and its boundaries are as follows : posteriorly, the upper border of the pons ; anteriorly, the optic commissure ; and, laterally, the crus cerebri and optic tract, in this order from behind forwards. The following parts lie within this space, in the order named, from behind forwards :

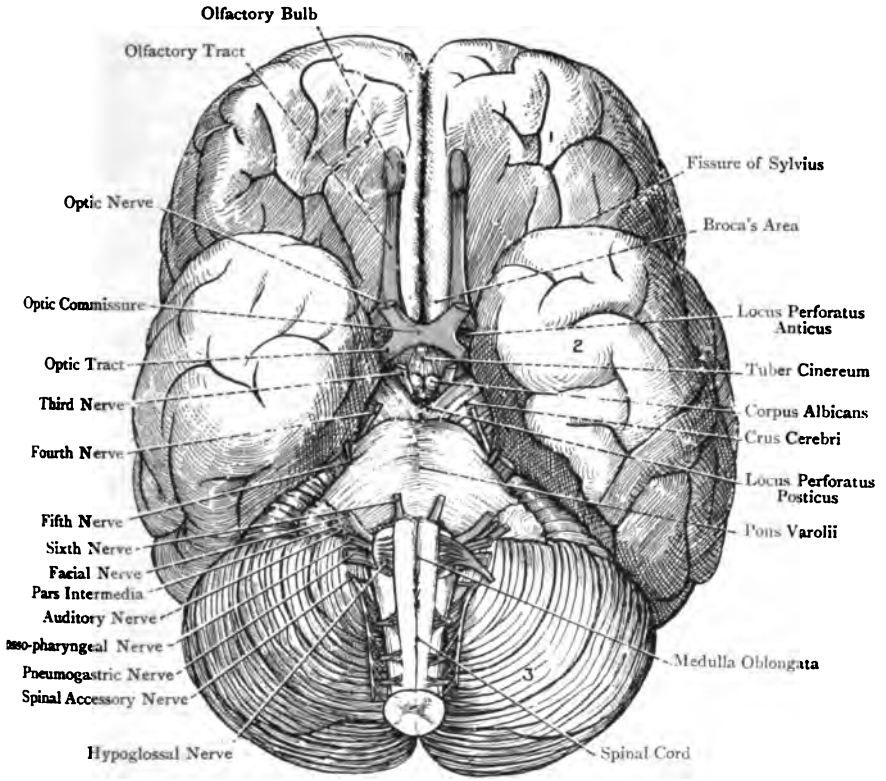


FIG. 539.—THE BASE OF THE ENCEPHALON, AND THE CRANIAL NERVES.

1, Frontal Lobe (Orbital Surface) ; 2, Temporal Lobe ; 3, Cerebellum.

(1) the locus perforatus posticus ; (2) the corpora albicantia or mammillaria ; and (3) the tuber cinereum, with the infundibulum. (The region which is directly above the interpeduncular space constitutes the third ventricle.)

The **locus perforatus posticus** corresponds to the posterior median angle of the diamond-shaped interpeduncular space, and it lies in a deep depression, called the **interpeduncular fossa,** or *fossa Tarini.*

The grey matter which forms it is perforated by openings for the passage of the postero-mesial branches of the posterior cerebral arteries.

The **corpora albicantia** or **mammillaria** are situated directly in front of the locus perforatus posticus, and present the appearance of small, white, pea-like bodies, lying close to the median line.

The **tuber cinereum** extends from the corpora albicantia to the optic commissure, and is composed of grey matter. The **infundibulum** is connected with the tuber cinereum close behind the optic commissure, and passes downwards to the posterior part of the pituitary body.

The **locus perforatus anticus** of each side coincides with the vallecula Sylvii at the inner end of the stem of the fissure of Sylvius. It lies outside the interpeduncular space, close to the outer aspect of the optic commissure. It consists of grey matter, which is perforated by openings for the passage of a few antero-mesial branches of the anterior cerebral artery, and numerous antero-lateral branches of the middle cerebral artery. These branches are destined for the nucleus caudatus and nucleus lenticularis of the corpus striatum, the grey matter of which nuclei comes to the surface of the brain at the locus perforatus anticus.

The medulla oblongata and pons Varolii occupy the basilar groove of the interior of the base of the skull; the cerebellar hemispheres occupy the cerebellar fossæ of the occipital bone; the temporal lobes of the cerebrum sink deeply into the lateral divisions of the middle fossa of the base of the skull; the orbital surfaces of the frontal lobes occupy the lateral divisions of the anterior fossa: the stem of the fissure of Sylvius faces the posterior or Sylvian border of the small wing of the sphenoid; the optic commissure rests upon the olivary eminence and optic groove of the sphenoid; and the olfactory bulb rests upon one half of the cribriform plate of the ethmoid bone.

Superficial or Surface Origins of the Cranial Nerves.

The **first** or **olfactory nerve** occupies the following positions: The **olfactory bulb** and **olfactory tract** occupy the olfactory sulcus on the orbital surface of the frontal lobe, near the great longitudinal fissure; and the olfactory filaments pass through the foramina of the cribriform plate of the ethmoid bone on their way from the olfactory cells of the olfactory mucous membrane to the olfactory bulb. Posteriorly the olfactory tract divides into two roots, mesial and lateral. The *mesial root* curves inwards behind the area of Broca to the callosal gyrus. The *lateral root* passes backwards and outwards across the outer part of the locus perforatus anticus. The triangular area of grey matter, which is situated between the diverging roots of the olfactory tract, is called the *trigonum olfactorium*. It is sometimes spoken of as the *middle* or *grey root* of the olfactory tract. The **area of Broca** is situated in front of the mesial

(inner) root of the olfactory tract, and is continuous with the callosal gyrus.

The **optic tract** curves round the crus cerebri from without inwards. The two optic tracts, having converged, are connected by the **optic commissure,** which lies at the anterior part of the interpeduncular space. The **optic nerve** is connected with the lateral extremity of the front part of the optic commissure.

The **third** or **oculo-motor nerve** emerges through the oculo-motor sulcus on the inner aspect of the crus cerebri, just above or in front of the pons Varolii, and close to the locus perforatus posticus.

The **fourth, pathetic,** or **trochlear nerve,** having emerged from the upper part of the superior medullary velum, or valve of Vieussens, makes its appearance in the interval between the crus cerebri internally and the temporal lobe externally.

The **fifth, trigeminal,** or **trifacial nerve** consists of two roots, which emerge, close together, from the lateral aspect of the ventral surface of the pons Varolii. The sensory root is large, and the motor root, which is small, lies above and slightly internal to the sensory root.

The **sixth** or **abducent nerve** emerges at the lower border of the pons Varolii, just external to the pyramid of the medulla oblongata.

The **seventh** or **facial nerve** (*portio dura*) emerges at the lower border of the pons, in front of the restiform body of the medulla oblongata.

The **eighth** or **auditory nerve** (*portio mollis*) likewise emerges at the lower border of the pons, in front of the restiform body of the medulla oblongata. It lies on the outer side of the facial nerve.

The **pars intermedia of Wrisberg** is a small nerve which appears between the facial and auditory nerves.

The **ninth** or **glosso-pharyngeal nerve** emerges, in the form of about six fasciculi, from the postero-lateral sulcus of the medulla oblongata, between the olivary body and the restiform body, immediately below the facial nerve.

The **tenth** or **pneumogastric nerve** lies directly below the glosso-pharyngeal nerve, and emerges by several fasciculi from the postero-lateral sulcus of the medulla oblongata in front of the restiform body.

The **eleventh** or **spinal accessory nerve** has several roots which lie below the fasciculi of the pneumogastric nerve. These emerge from the medulla oblongata and the upper part of the lateral column of the spinal cord as low as the level of the fifth cervical nerve, and they lie below the fasciculi of the pneumogastric nerve, and external to, or in front of, the posterior roots of the adjacent cervical spinal nerves.

The **twelfth** or **hypoglossal nerve** emerges by several fasciculi through the antero-lateral sulcus of the medulla oblongata, between the pyramid and the olivary body. These fasciculi lie in line with the sixth nerve superiorly.

Arteries at the Base of the Encephalon.—The arteries which supply the brain are the two vertebral and the two internal carotid arteries.

The **vertebral arteries** incline inwards as they ascend on the ventral aspect of the medulla oblongata, and at the lower border of the pons Varolii they unite to form the basilar artery. The branches of each vertebral artery to be noted are as follows: (1) the *posterior spinal branch*, which arises from the main vessel immediately after it has pierced the dura mater, and descends upon the side of the medulla oblongata to the spinal cord; (2) the *anterior spinal branch*, which arises higher up than the preceding, and passes downwards and inwards on the ventral aspect of the medulla oblongata to unite with its fellow and form the *anterior spinal artery*; and (3) the *posterior inferior cerebellar branch*, of large size, which arises from the main vessel near the pons, and passes backwards round the medulla oblongata to enter the vallecula of the cerebellum.

The **basilar artery** extends from the lower border of the pons Varolii to the upper border, occupying the basilar groove on its ventral surface. It is formed by the union of the two vertebral arteries, and terminates by dividing into the two posterior cerebral arteries. The branches of the basilar artery to be noted on either side are as follows: (1) the *transverse arteries of the pons*; (2) the *internal auditory artery*, which accompanies the auditory nerve through the meatus auditorius internus; (3) the *anterior inferior cerebellar artery*, which arises from the basilar about its centre, and passes backwards to the inferior surface of the cerebellar hemisphere; (4) the *superior cerebellar artery*, which arises from the basilar near its termination, and passes outwards close to the upper border of the pons, and then round the outer side of the crus cerebri to the superior surface of the cerebellar hemisphere; and (5) the *posterior cerebral artery*, which arises from the termination of the basilar, and passes outwards, parallel to the superior cerebellar artery, and then round the outer side of the crus cerebri to the inferior surface of the occipital lobe. The posterior cerebral and superior cerebellar arteries are separated from each other by the third and fourth cranial nerves, the latter being the external of the two. The branches of the posterior cerebral artery to be noted, amongst others, are as follows: (1) *postero-mesial*, which pass to the locus perforatus posticus; (2) *postero-lateral*, which pass round the outer side of the crus cerebri; and (3) *posterior choroidal*, which pass to the upper part of the choroidal fissure.

The **internal carotid artery** of each side appears at the vallecula Sylvii, and there divides into the anterior and middle cerebral arteries. Near its termination it gives off the **posterior communicating artery**, which passes backwards to join the posterior cerebral artery. It also gives off the **anterior choroidal artery**, which passes backwards and outwards between the crus cerebri and the uncinate gyrus to the lower and anterior part of the choroidal fissure.

The **anterior cerebral artery** passes forwards and inwards, and enters the great longitudinal fissure. As it is about to enter that fissure it is connected with its fellow of the opposite side by the **anterior communicating artery,** which is short, but of fairly large size. Amongst other branches the following are to be noted arising from the anterior cerebral artery: (1) *antero-mesial,* few and inconstant, and (2) *antero-lateral,* both of which pass to the locus perforatus anticus.

The **middle cerebral artery,** of large size, sinks into the fissure of Sylvius, which it traverses in an outward direction. Before disappearing into the fissure *antero-lateral ganglionic branches* are to be

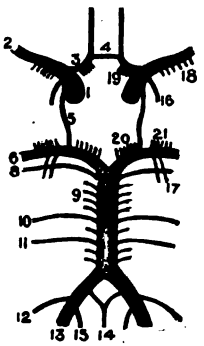


FIG. 540.—THE ARTERIES AT THE BASE OF THE BRAIN, AND THE CIRCLE OF WILLIS.

1. Internal Carotid
2. Middle Cerebral
3. Anterior Cerebral
4. Anterior Communicating
5. Posterior Communicating
6. Posterior Cerebral
7. Basilar
8. Superior Cerebellar
9. Transverse Pontine
10. Internal Auditory
11. Anterior Inferior Cerebellar
12. Posterior Inferior Cerebellar
13. Vertebral
14. Anterior Spinal
15. Posterior Spinal
16. Anterior Choroid
17. Posterior Choroid
18. Central or Ganglionic
19. Central or Ganglionic
20. Central or Ganglionic (Postero-mesial)
21. Central or Ganglionic (Postero-lateral)

noted arising from it, which are arranged in two sets, *internal striate* and *external striate,* which are destined chiefly for the component parts of the corpus striatum.

Circle of Willis.—This is an important communication between the vertebral and internal carotid arterial systems at the base of the brain, which is situated around the interpeduncular space. It is not actually a circle, though so named, but is a heptagon—that is to say, it has seven angles and seven sides.

Commencing at the median line posteriorly, and proceeding forwards on either side to the median line in front, at the great longitudinal fissure, the component arteries of the circle are as follows: (1) the basilar, (2) the posterior cerebral, (3) the posterior communicating, (4) the internal carotid, (5) the anterior cerebral, and (6) the anterior communicating. The connection between the

two posterior cerebral arteries is effected by means of the basilar artery; the connection between the posterior cerebral and internal carotid arteries is effected by means of the posterior communicating artery; and the connection between the two anterior cerebral arteries is effected by means of the anterior communicating artery. These communications serve to insure a regular supply of arterial blood to the brain in cases of obstruction to one or other of the

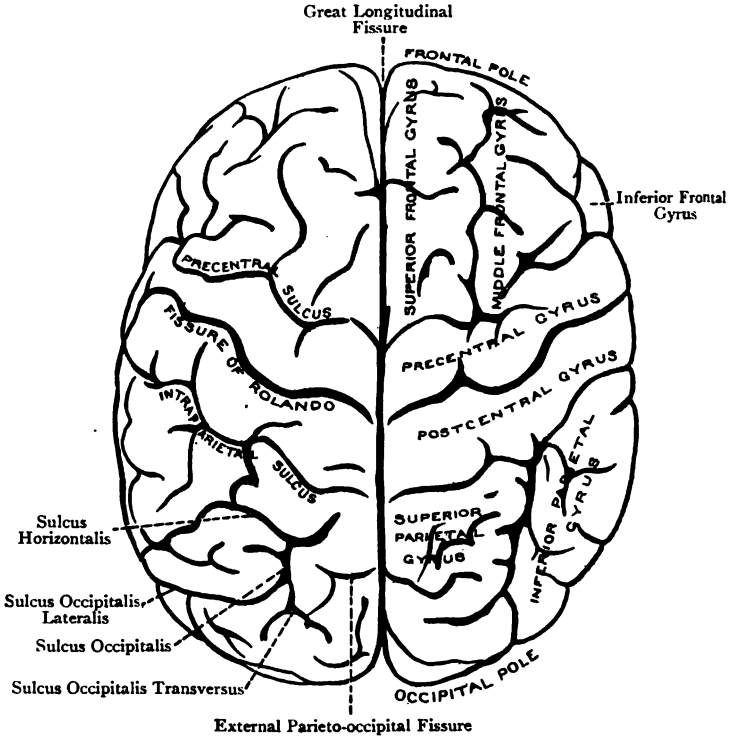


FIG. 541.—THE CEREBRAL HEMISPHERES (SUPERIOR VIEW).

principal arterial trunks. The communications also serve to equalize the circulation of blood through the different parts of the brain.

Superior Surface of the Brain.—The brain is ovoid superiorly, its greatest breadth corresponding to the positions of the parietal eminences of the parietal bones. In the median line it presents a deep cleft, called the **great longitudinal fissure,** which extends from the front to the back, and divides it into two **hemispheres,** right and left. This fissure is occupied by a process of the dura mater, called the **falx cerebri,** and the corpus callosum lies at its deep part. In front of the corpus callosum the fissure extends down to, and is

visible on, the base of the brain, but behind the corpus callosum it only extends to the level of the tentorium cerebelli, which separates the cerebellum from the posterior parts of the cerebral hemispheres. The fissure, therefore, in this situation is not visible inferiorly until the cerebellum and the tentorium cerebelli have been removed.

Each **hemisphere** is semi-ovoid, its mesial or inner surface being flat. The anterior and posterior extremities are rounded, the former being the thicker of the two. The anterior extremity is known as the **frontal pole,** and the posterior extremity forms the **occipital pole.** The surface of each hemisphere consists of grey matter, which is spoken of as the **cerebral cortex.** Superiorly and externally it is convex in adaptation to the concavity of the vault of the cranium. It is broken up into a number of tortuous eminences, called **gyri** or **convolutions,** and these are separated from each other by clefts, called **sulci** or **fissures.** The surfaces of the gyri which bound the sulci are covered with grey matter, like their exterior. The pia mater closely covers the gyri, and also dips into the sulci, so as to cover the opposed surfaces of the gyri. The arachnoid membrane, however, does not dip into the sulci, but passes over them. The sulci are of various depths, but the average depth may be said to be $\frac{1}{2}$ inch.

RHOMBENCEPHALON.

1. The Medulla Oblongata.

The **medulla oblongata** or **bulb** (*myelencephalon*) is the continuation upwards of the spinal cord, and it extends from the lower margin of the foramen magnum to the lower border of the pons Varolii. Its direction is upwards and slightly forwards, and it measures 1 inch in length, $\frac{3}{4}$ inch in breadth at the widest part, and rather more than $\frac{1}{2}$ inch in thickness. Inferiorly its girth corresponds with that of the spinal cord, but it widens superiorly, so that its shape is somewhat pyramidal. Its anterior or ventral surface lies in the basilar groove of the occipital bone, and its posterior or dorsal surface is directed towards the vallecula of the cerebellum. It is composed of two symmetrical halves, its bilateral symmetry being indicated superficially by upward prolongations of the anterior and posterior median fissures of the spinal cord. The *anterior median fissure* extends as high as the lower border of the pons Varolii, where it expands slightly and ends in a blind recess, called the *foramen cæcum.* The lower part of the fissure is crossed by several bundles of fibres which are derived from the inner three-fourths of each pyramid, and the decussation thus formed is known as the **decussation of the pyramids.** The *posterior median fissure* only extends over the lower half of the medulla, and it terminates at the level of the calamus scriptorius.

The lower half of the medulla contains a prolongation of the central canal of the cord, which opens at the calamus scriptorius into the lower part of the fourth ventricle. This portion of the medulla is known as the *closed part*. In the upper half of the medulla the grey matter comes to the surface posteriorly over the lower portion of the floor of the fourth ventricle, and the upper half of the medulla is known as the *open part*.

In series with the anterior nerve-roots of the spinal cord the fasciculi of the hypoglossal nerve emerge from the medulla along a groove, called the *antero-lateral sulcus*, which is situated in front of the olivary body. These fasciculi, however, unlike those of the anterior nerve-roots of the cord, emerge in a straight line. In series

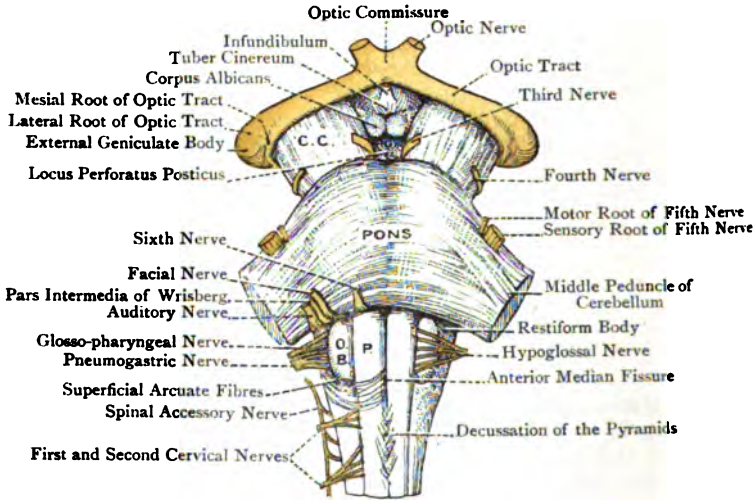


FIG. 542.—THE MEDULLA OBLONGATA, PONS VAROLII, AND INTERPEDUNCULAR REGION.

C.C., Crus Cerebri ; P., Pyramid ; O.B., Olivary Body.

with the posterior nerve-roots of the spinal cord the fasciculi of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves appear. These numerous fasciculi are connected with the medulla along a groove, called the *postero-lateral sulcus*, which is continuous with the corresponding sulcus of the spinal cord, and is situated behind the olivary body. The antero-lateral and postero-lateral sulci, along with the nerve-fasciculi connected with them, divide the corresponding half of the medulla into three areæ—anterior, lateral, and posterior.

Anterior Area.—This area is situated between the anterior median fissure and the antero-lateral sulcus with the fasciculi of the hypoglossal nerve. It constitutes the **pyramid** of the medulla.

As regards position, it is continuous with the anterior column of the spinal cord, and it is composed of bundles of longitudinal nerve-fibres. Inferiorly it is narrow, but superiorly it expands, and at the lower border of the pons it undergoes a slight constric-

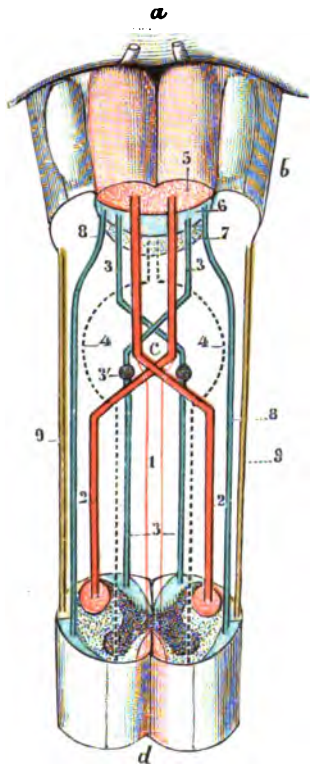


FIG. 543.—THE DECUSSATION OF THE PYRAMIDS. SCHEME REPRESENTING THE PASSAGE OF THE VARIOUS TRACTS FROM THE SPINAL CORD TO THE MEDULLA (L. TESTUT'S 'ANATOMIE HUMAINE').

a. Pons Varolii
b. Medulla Oblongata (anterior aspect)
c. Decussation of the Pyramids
d. Section of the Cervical Spinal Cord
1. Direct Pyramidal Tract
2. Crossed Pyramidal Tract
3. Sensory Tract
3'. Nucleus Gracilis et Nucleus Cuneatus
4. Antero-lateral Ground-Bundle
5. Anterior Pyramid
6. Fillet
7. Posterior Longitudinal Bundle
8. Tract of Gowers
9. Direct Cerebellar Tract

tion, after which it enters the pons. Its fasciculi now become separated, and, after traversing the pons, they are gathered up again at its upper border into the corresponding crus cerebri. The two pyramids, right and left, constitute the great **motor tracts** of the medulla. Each pyramid divides inferiorly into two

parts, an external, which is small, and an internal, of large size. The fibres of the *external* portion are continued into the corresponding anterior column of the spinal cord, where they constitute the **direct pyramidal tract,** which lies close to the anterior median fissure. The fibres of the *internal* portion cross to the opposite side in the lower part of the anterior median fissure of the medulla, and then they sink into the posterior part of the lateral column of the spinal cord on the side to which they have crossed, where they constitute the **crossed pyramidal tract.** The intercrossing which takes place in the lower part of the anterior median fissure of the medulla is called the **decussation of the pyramids.** It usually involves three-fourths of the fibres of each pyramid. The only part of the anterior column of the spinal cord which is continued into the corresponding pyramid of the medulla is the direct pyramidal tract. The remainder of the anterior column of the cord, namely, the anterior ground-bundle, on entering the medulla, takes up a deep position behind and external to the pyramid.

The superficial surface of each pyramid is crossed, above the level of the decussation, by the *anterior superficial arcuate fibres,* which emerge from the anterior median fissure, and arch outwards and backwards to the restiform body. The sixth cranial nerve emerges at the lower border of the pons Varolii immediately external to the pyramid and in line with the fasciculi of the hypoglossal nerve.

Lateral Area of the Medulla.—This area is situated between the antero-lateral sulcus, with the fascieuli of the hypoglossal nerve, and the postero-lateral sulcus, with the fasciculi of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves. Superficially it presents superiorly an oval swelling, called the **olivary body** or **eminence,** and inferiorly (*lateral tract*) it appears to be a prolongation of the lateral column of the spinal cord. This, however, is far from being the case. The crossed pyramidal tract of the lateral column of the cord sweeps obliquely across to form the larger and internal portion of the pyramid of the medulla on the opposite side ; and the direct cerebellar tract of the lateral column of the cord passes obliquely backwards into the restiform body of the medulla on the same side. The portions, therefore, of the lateral column of the cord which are prolonged into the lower part of the lateral area of the medulla (lateral tract) are : (1) the tract of Gowers, and (2) the lateral ground-bundle. These ascend to the lower part of the olivary body, where they are crossed by the anterior superficail arcuate fibres. The majority of their fibres then sink beneath the olivary body in their upward course, but a few of them ascend superficially close behind it on their way to the pons Varolii. The lateral area of the medulla below the olivary body therefore consists of the tract of Gowers and the lateral ground-bundle, both of which are prolonged from the lateral column of the cord of the same side.

Olivary Body or Eminence.—This, as stated, is an oval swelling, situated in the upper part of the lateral area of the medulla. Its

long axis is placed vertically, and in this direction it measures about ½ inch. Superiorly it comes very nearly into contact with the pons Varolii, from which it is separated by a deep transverse groove; and inferiorly the anterior superficial arcuate fibres arch over it. The fasciculi of the hypoglossal nerve are on its mesial side, and posteriorly those of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves appear, with the intervention of some ascending fibres derived from the lateral column of the spinal cord. The seventh or facial and eighth or auditory nerves make their appearance at the lower border of the pons, external to the upper end of the olivary body, the facial nerve being the *internal* of the

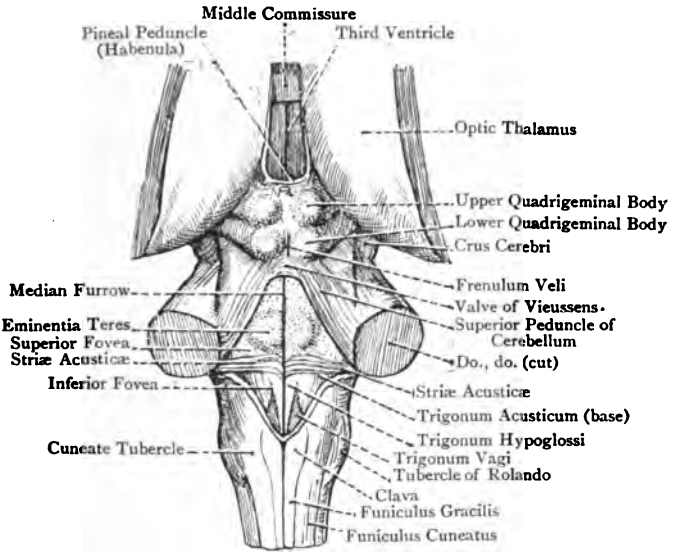


FIG. 544.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS

two, and the pars intermedia of Wrisberg lies between it and the auditory nerve.

Posterior Area of the Medulla.—This area is situated behind the postero-lateral sulcus, with the fasciculi of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves. Posteriorly it extends to the posterior median fissure of the lower or closed part of the medulla, and to the lateral boundary of the lower portion of the fourth ventricle in the upper or open part of the medulla. Like the lateral area, it is divided into two portions, upper and lower. The *lower portion* is in direct continuity with the posterior column of the spinal cord, and it presents upward prolongations of the columns of Goll and of Burdach. The prolongation of Goll's column is known in the medulla as the **funiculus gracilis,** and that

of Burdach's column as the **funiculus cuneatus,** these two funiculi being separated by an upward continuation of the posterior intermediate furrow of the cord. The funiculus gracilis is the internal of the two funiculi. When the funiculi reach the level of the calamus scriptorius each becomes enlarged. The enlargement formed by the funiculus gracilis is called the **clava,** and that formed by the funiculus cuneatus is called the **cuneate tubercle.** As the medulla opens out at the calamus scriptorius to form the lower part of the floor of the fourth ventricle the clavæ diverge, and the central canal of the spinal cord appears in the angle between them. Beneath the funiculus gracilis and funiculus cuneatus, as well as beneath the clava and cuneate tubercle, there is in each case an elongated nucleus of grey matter. These collections of grey matter are called the **nucleus gracilis** and **nucleus cuneatus** respectively. The fibres of the two funiculi terminate at intervals in ramifications which are intimately connected with the cells of these nuclei. External to the funiculus cuneatus, between it and the fasciculi of the spinal accessory nerve, there is a third funiculus which is not represented in the posterior column of the spinal cord. It is called the **funiculus of Rolando,** and is caused by the substantia gelatinosa of Rolando coming close to the surface in the lower half of the medulla, and giving rise to a longitudinal elevation. Inferiorly it is narrow, but superiorly it expands and terminates in an enlarged extremity, called the **tubercle of Rolando.** The delicate layer of longitudinal fibres covering the funiculus of Rolando represents the spinal or ascending root of the fifth cranial nerve.

The *upper portion* of the posterior area presents, on either side, a round tract, called the **restiform body,** which is situated between the lateral margin of the lower half of the floor of the fourth ventricle and the fasciculi of the pneumogastric and glosso-pharyngeal nerves. Its direction is upwards, outwards, and backwards into the corresponding hemisphere of the cerebellum, of which it constitutes the *inferior peduncle.* It derives its fibres from the following sources: (1) the direct cerebellar tract of the lateral column of the spinal cord; (2) the anterior superficial arcuate fibres, which emerge from the anterior median fissure of the medulla; (3) the posterior superficial arcuate fibres, which arise from the cells of the nucleus gracilis and nucleus cuneatus; and (4) the cerebello-olivary fibres, to be presently described. The restiform body is the great tract of communication between the medulla oblongata and spinal cord on the one hand and the cerebellum on the other.

Arcuate Fibres of the Medulla.—These fibres are arranged as superficial and deep, but the former only will be described here. The **superficial arcuate fibres** are arranged in two sets, anterior and posterior. The *anterior superficial arcuate fibres* emerge from the anterior median fissure, and curve outwards over the pyramid, the lower part of the olivary body, and the adjacent lower portion of the lateral area of the medulla. Thereafter they pass backwards and upwards into the restiform body. The *posterior superficial*

arcuate fibres, as just stated, arise from the cells of the nucleus gracilis and nucleus cuneatus, and, like the anterior, enter the restiform body.

Summary.—The medulla oblongata is composed of two symmetrical halves, separated superficially by the anterior and posterior median fissures, the former traversing its whole extent, and the latter being confined to its lower half. It is entirely closed in front, but posteriorly it is divisible into a *closed part*, representing the lower half, and an *open part*, representing the upper half. Over the open portion the grey matter comes to the surface, and forms the lower half of the floor of the fourth ventricle. Each half of the medulla presents two sulci—antero-lateral and postero-lateral. The antero-lateral sulcus gives exit to the fasciculi of the hypoglossal nerve, and in line with these superiorly is the sixth cranial nerve. The postero-lateral sulcus transmits the fasciculi of the spinal accessory, pneumogastric and glosso-pharyngeal nerves, in this order from below upwards. Above these are the seventh or facial and eighth or auditory nerves, the facial being the internal of the two, and the pars intermedia of Wrisberg intervenes between it and the auditory. By means of the two sulci just stated, with the corresponding nerve-fasciculi, each half of the medulla is divided into three areæ—anterior, lateral, and posterior. The **anterior area** forms the pyramid, which inferiorly is disposed as the direct and crossed pyramidal tracts. The fibres of the direct pyramidal tract are continued into the anterior column of the spinal cord of the same side, where they lie close to the anterior median fissure, and form the direct or anterior pyramidal tract, or column of Türck. The fibres of the crossed pyramidal tract sweep across the lower part of the anterior median fissure, and then descend in the posterior part of the lateral column of the spinal cord of the opposite side, of which they constitute the crossed or lateral pyramidal tract. The intercrossing of the fibres of the pyramids in the lower part of the anterior median fissure of the medulla constitutes the decussation of the pyramids. Above this decussation each pyramid is crossed in an outward direction by the anterior superficial arcuate fibres. The **lateral area** is subdivided into two parts—upper and lower. The upper part is occupied by the olivary body, and the lower part (lateral tract) by a strand of fibres derived from the tract of Gowers and the lateral basis bundle of the lateral column of the spinal cord of the same side. The lower part of the olivary body and the adjacent portion of the lateral tract are crossed by the anterior superficial arcuate fibres. The **posterior area** of the medulla is subdivided into two parts—lower or closed, and upper or open. The closed part, on each side, consists of the following strands, named in order from the posterior median fissure outwards: (1) funiculus gracilis, ending superiorly in the clava, and having the nucleus gracilis subjacent to it; (2) funiculus cuneatus, ending superiorly in the cuneate tubercle, and having the nucleus cuneatus subjacent to it; and (3) the funiculus of Rolando, ending superiorly in the tubercle of Rolando, and having superficial to it the fibres of the spinal or ascending root of the fifth nerve. The open part of the posterior area presents, on either side, the restiform body.

The superficial arcuate fibres are arranged in two sets—anterior, which emerge from the anterior median fissure and curve outwards to the restiform body, and posterior, which arise from the cells of the nucleus gracilis and nucleus cuneatus, and likewise enter the restiform body.

Internal Structure of the Medulla.—The medulla oblongata is composed of two kinds of nervous matter, white and grey, the white being disposed chiefly on the surface, and the grey in the interior, except over the lower half of the floor of the fourth ventricle, where it comes to the surface.

The principal superficial longitudinal tracts of **white matter** on either side are the pyramid, funiculus gracilis, funiculus cuneatus,

and restiform body, all of these being associated with the spinal cord. There are, however, other longitudinal strands which are peculiar to the medulla, the chief of which are the fillets or lemnisci, right and left.

A large part of the **grey matter** is arranged as the formatio reticularis, but it also exists as (1) a thick layer around the central canal in the closed part of the medulla, and on the floor of the fourth ventricle in the open part; (2) the substantia gelatinosa of Rolando; (3) the nuclei graciles; (4) the nuclei cuneati; (5) the inferior olivary nuclei; and (6) the arcuate nuclei.

Lower or Closed Part of the Medulla.—An important change in the internal structure of this part is produced by the decussation of

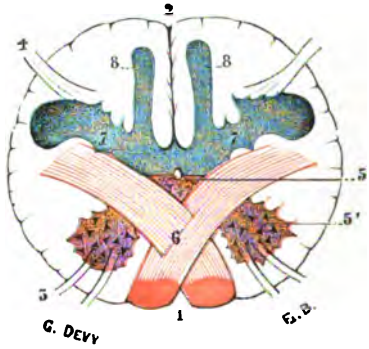


FIG. 545.—SECTION OF THE MEDULLA OBLONGATA AT THE LEVEL OF THE DECUSSATION OF THE PYRAMIDS (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Posterior Median Fissure
3. Motor Roots
4. Sensory Roots
5. Base of the Anterior Cornu from which the Caput, 5', has been detached by the passage of the crossed Pyramidal Tract
6. Decussation of the crossed Pyramidal Tracts
7. Posterior Cornu
8. Nucleus Gracilis

the pyramids. The fasciculi of the crossed pyramidal tract pass through the anterior grey cornu of the cord, and then cross the anterior median fissure of the medulla to the opposite pyramid. The anterior grey cornu is thus broken up, and its caput becomes separated from its basal part. The basal part remains on the ventral and lateral aspects of the central canal. The detached caput, being displaced laterally, and thus coming close to the caput cornu posterioris, is broken up into a network of grey matter, containing nerve-cells, and traversed by white fibres. This network is known as the **formatio reticularis.** The posterior grey cornu also becomes displaced laterally by the increase in size of the funiculus gracilis and funiculus cuneatus, and it comes to lie at right angles to the posterior median fissure. Its caput undergoes enlargement, and lies close to the surface, and the substantia gela-

tinosa of Rolando gives rise to the funiculus and tubercle of Rolando. The basal part of the posterior grey cornu remains on the dorsal and lateral aspects of the central canal; but its cervix becomes intersected by variously-disposed fibres, and is thus broken up, like the caput of the anterior grey cornu, into a formatio reticularis. This formatio reticularis cuts off the caput cornu posterioris from the rest of the grey matter, and it joins the formatio reticularis formed in the caput cornu anterioris.

The grey matter of the nucleus gracilis is an extension of the grey matter of the base of the posterior cornu. The nucleus gracilis terminates just above the level of the calamus scriptorius. The grey matter of the nucleus cuneatus is originally an extension

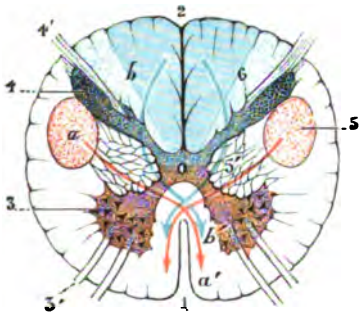


FIG. 546.—SECTION OF THE MEDULLA OBLONGATA THROUGH THE LOWER PART OF THE DECUSSATION OF THE PYRAMIDS (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Posterior Median Fissure
3. Anterior Cornu
3. Anterior Nerve-roots
4. Posterior Cornu
4. Posterior Nerve-roots
5. Crossed Pyramidal Tract
6. Column of Burdach

The red arrows, *a*, *a'*, indicate the paths taken by the crossed Pyramidal Tracts at the level of the decussation of the Pyramids; and the blue arrows, *b*, *b'*, indicate the paths of the Sensory Fibres.

of the grey matter of the base of the posterior cornu. This nucleus extends a little higher than the nucleus gracilis. The fibres of the funiculus gracilis and funiculus cuneatus, as has been stated, terminate at intervals in ramifications which are intimately connected with the cells of these two nuclei. External to the nucleus cuneatus there is an additional collection of grey matter, known as the *accessory* or *external cuneate nucleus*.

Deep Arcuate Fibres.—These fibres arise from the cells of the nucleus gracilis and nucleus cuneatus on their deep aspects. They pass forwards and inwards in a curved manner to the median raphé of the medulla. Here they cross to the opposite side, decussating with those which come from that side immediately above the level of the decussation of the pyramids, but on a more posterior plane. This intercrossing is known as the **sensory de-**

cussation (decussation of the fillets), as distinguished from the decussation of the pyramids, which is known as the **motor decussation.** Having crossed the median line, the deep arcuate fibres give rise to a well-marked longitudinal tract, which is called the **fillet,** or *lemniscus.* This tract is situated immediately behind the pyramid, lying between it and the posterior longitudinal bundle which contains the anterior ground-bundle of the anterior column of the spinal cord. The order of these longitudinal tracts, from before backwards, is as follows: (1) pyramid, (2) fillet, and (3) posterior longitudinal bundle.

Posterior Longitudinal Bundle.—This is situated behind the fillet, and its fibres, to a large extent, are derived from the anterior ground-

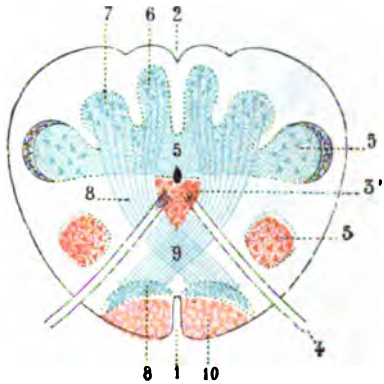


FIG. 547.—TRANSVERSE SECTION PASSING THROUGH THE SENSORY DECUSSATION (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Posterior Median Fissure
3, 3¹. Caput and Base of Anterior Cornu (in red)
4. Hypoglossal Nerve
5, 5. Caput and Base of Posterior Cornu
6. Nucleus Gracilis
7. Nucleus Cuneatus
8, 8. Fillet, or Sensory Tract
9. Sensory Decussation
10. Pyramidal Tract

bundle of the anterior column of the spinal cord of the same side. As a result of the decussation of the pyramids, the anterior ground-bundle is displaced backwards.

Olivary Nuclei.—These collections of grey matter are three in number, namely, inferior, mesial, and dorsal accessory. The **inferior olivary nucleus** is situated within the olivary body. When a transverse section of that body is made, the nucleus appears as a wavy lamina of grey matter, so disposed as to constitute an incomplete capsule which encloses white matter. The deficient part of the lamina is known as the ***hilum***, and it looks towards the median line. Large numbers of white fibres pass through it, which form the *olivary peduncle.* The **mesial** and **dorsal accessory olivary nuclei** are two small grey bands, which are situated on the mesial and

dorsal aspects of the inferior olivary nucleus. The grey matter of these three olivary nuclei contains many nerve-cells. Some of the fibres related to the nuclei terminate in these cells, but others pass through the grey matter.

Upper or Open Part of the Medulla—Restiform Body.—This takes the place superiorly of the funiculus gracilis and funiculus cuneatus. Its direction is upwards, outwards, and backwards into the hemisphere of the cerebellum, of which it constitutes the inferior peduncle. It becomes conspicuous above the limit of the cuneate tubercle, and forms the lateral boundary of the lower part of the floor of the fourth ventricle. Its fibres are derived from the following sources: (1) the direct cerebellar tract; (2) the anterior superficial arcuate fibres; (3) the posterior superficial arcuate fibres; and (4) the cerebello-olivary fibres. The *direct cerebellar tract*, as it approaches the olivary body, passes obliquely backwards, and its fasciculi, having covered the tubercle of Rolando, enter the outer part of the restiform body. The *anterior superficial arcuate fibres* of one side arise from the lower parts of the nucleus gracilis and nucleus cuneatus of the opposite side, where they really belong to the internal or deep arcuate fibres. With these latter they cross at the median raphé, decussating with their fellows of the opposite side. Instead, however, of entering the fillet, they pass forwards in the anterior median fissure, and then curve outwards over the pyramid, the lower part of the olivary body, and the adjacent portion of the lateral tract, after which they enter the restiform body. A few of the anterior superficial arcuate fibres may pass through the pyramid, or may appear between it and the olivary body. The *posterior superficial arcuate fibres* arise from the nucleus gracilis and nucleus cuneatus, and enter the restiform body of the same side, whilst, as stated, the anterior superficial arcuate fibres cross to enter the restiform body of the opposite side.

The *cerebello-olivary fibres* enter largely into the formation of the restiform body, of which they constitute the deep part. They represent the fibres of the olivary peduncle of either side, and they emerge in large numbers through the hilum of the inferior olivary nucleus. They then cross at the median raphé, and pass through or around the inferior olivary nucleus of the opposite side. Thereafter they pass backwards into the deep part of the restiform body, through which they course to the cortex of the cerebellum, where they are regarded as arising, (it may be from the cells of Purkinje). The cerebello-olivary fibres are therefore to be regarded as centrifugal or efferent fibres passing from the cells of the cerebellar cortex of one side to the cells of the inferior olivary nucleus of the opposite side.

The **arcuate nucleus** is of small size, and is situated partly in front of the pyramid under cover of the anterior superficial arcuate fibres, just above the decussation of the pyramids, and partly, at a higher level, on the inner side of the pyramid, close to the anterior median fissure. Some of the anterior superficial arcuate fibres are

regarded as terminating in its cells, and others of these fibres as arising from its cells.

Formatio Reticularis of the Medulla.—This is situated behind the pyramid and the olivary body. It is divided into two parts, lateral and mesial, by the fasciculi of the hypoglossal nerve on their way to the antero-lateral sulcus. The *lateral* portion is situated behind the olivary body, and is called the **formatio reticularis**

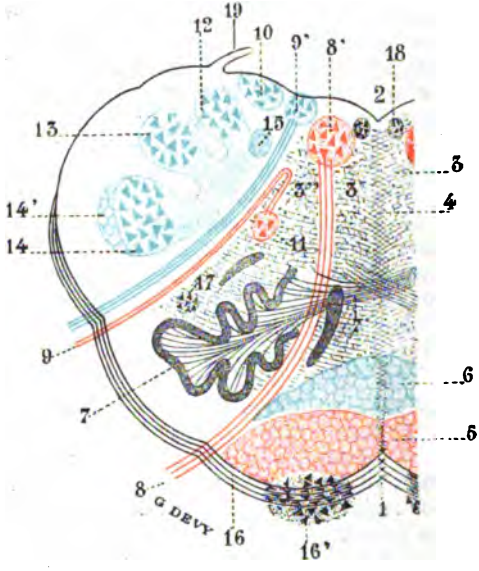


FIG. 548.—THE FORMATIO RETICULARIS OF THE MEDULLA OBLONGATA, SHOWN BY A HORIZONTAL SECTION PASSING THROUGH THE MIDDLE OF THE OLIVARY BODY (DEMI-SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Fourth Ventricle
3. Formatio Reticularis
3'. Reticularis Alba
3''. Reticularis Grisea
4. Raphé
5. Anterior Pyramid
6. Fillet
7. Inferior Olive, with the two Accessory Nuclei
7'. Peduncle of Olivary Body
8. Hypoglossal Nerve
8'. Hypoglossal Nucleus
9. Pneumogastric Nerve
9'. Terminal Nucleus of Pneumogastric Nerve
10. External Dorsal Auditory Nucleus
11. Nucleus Ambiguus
12. Nucleus Gracilis
13. Nucleus Cuneatus
14. Caput of Posterior Cornu
14'. Lower Sensory Root of Fifth Nerve
15. Fasciculus Solitarius
16. External Anterior Arcuate Fibres
16'. Arcuate Nucleus
17. Lateral Nucleus
18. Nucleus of Fasciculus Teres

grisea (grey formation), from the large amount of grey matter and nerve-cells which it contains. Its grey matter is continuous with that of the formatio reticularis of the spinal cord. The *mesial* portion is situated behind the pyramid, and is called the **formatio reticularis alba** (white formation). It contains very little grey matter and only a few nerve-cells. Both divisions of the formatio reticularis are intersected by nerve-fibres, arranged transversely and longitudinally. The *transverse fibres* are the internal or deep

arcuate fibres on their way to the sensory decussation, or decussation of the fillets, at the median raphé. The *longitudinal fibres* are disposed in two groups. Those which traverse the formatio grisea are mainly derived from the tract of Gowers and the lateral ground-bundle of the spinal cord; and those which pass through the formatio alba belong to the fillet and the posterior longitudinal bundle.

Raphé of the Medulla.—The raphé occupies the median line, and is composed of fibres which pass in various directions, as they cross from side to side. It contains numerous multipolar nerve-cells.

Central Canal of the Medulla.—This occupies the closed or lower part of the medulla. As it ascends it is gradually displaced backwards by the decussation of the pyramids and the sensory decussation or decussation of the fillets. It is surrounded by a thick layer of grey matter, which is continuous with the basal portions of the anterior and posterior grey cornua of the spinal cord. Superiorly, at the level of the calamus scriptorius, it opens into the fourth ventricle at its lower pointed end; and the surrounding grey matter becomes spread out upon the ventricular floor, where it is covered by ependyma.

Areæ of the Medulla.—The three areæ—anterior, lateral, and posterior—which have been already described as regards the structures which they present superficially, are clearly seen in their entire extent only when transverse sections of the medulla have been made. The divisions into areæ are effected by the fasciculi of the hypoglossal and pneumogastric nerves, after their fibres leave their nuclei of origin in the lower or medullary portion of the floor of the fourth ventricle. The **anterior area** lies between the hypoglossal fasciculi and the median raphé; the **lateral area** intervenes between the hypoglossal and pneumogastric fasciculi; and the **posterior area** is situated behind the pneumogastric fasciculi.

Relation of Chief Nerve-fasciculi of the Spinal Cord to the Medulla Oblongata.

Spinal Cord (Posterior Column).		Medulla Oblongata.
Column of Goll	=	Funiculus Gracilis.
Column of Burdach	=	Funiculus Cuneatus.
Spinal Cord (Lateral Column).		**Medulla Oblongata.**
Direct Cerebellar Tract	=	Restiform Body.
Tract of Gowers and Lateral Ground-bundle	=	Lateral Tract below Olivary Body.
Crossed Pyramidal Tract	=	Inner three-fourths of Opposite Pyramid.
Spinal Cord (Anterior Column).		**Medulla Oblongata.**
Direct Pyramidal Tract (Column of Türck)	=	Outer fourth of Pyramid of same Side.
Anterior Ground-bundle	=	Posterior Longitudinal Bundle of same Side.

Development.—The medulla oblongata is developed as a thickening of the wall of the myelencephalon, which is one of the divisions of the rhombencephalon.

2. The Pons Varolii.

The **pons Varolii** is situated above the medulla oblongata, and between the hemispheres of the cerebellum. With the exception of the restiform bodies, all the other parts of the medulla oblongata are prolonged into it. The pons presents two surfaces, ventral and dorsal, and two borders, upper and lower. The **ventral surface** rests upon the upper part of the basilar groove of the occipital bone and the dorsum sellæ of the sphenoid. It is convex from side to side, and from above downwards, and has a transversely-striated appearance, due to the disposition of its superficial fibres. Along the median line it presents the *basilar groove*, which extends from the lower to the upper border, and lodges the basilar artery. On either side of this groove the ventral surface is rendered prominent by the prolongation upwards of the pyramids of the medulla oblongata, and the basilar groove is chiefly due to this circumstance. The sensory and motor roots of the fifth nerve, lying close together, appear on the lateral aspect of the ventral surface, the small motor root being the upper of the two. The portion external to these two nerve-roots constitutes the middle peduncle of the cerebellum. It is composed of the transverse fibres of the pons, these on either side being collected into a large bundle, which passes backwards and outwards into the corresponding cerebellar hemisphere.

The **dorsal surface** is directed towards the cerebellum, and is flat. It is covered by grey matter, and is continuous with the dorsal surface of the open or upper part of the medulla oblongata. It forms the upper part of the floor of the fourth ventricle, and will be described in connection with that space. Suffice it to say in the meantime that it presents, on either side of the median line, (1) the fovea superior, (2) the eminentia teres, (3) a prolongation of the area acustica, (4) the locus cæruleus, and (5) the substantia ferruginea. The superior peduncles of the cerebellum, as they pass upwards, lie on the dorsal surface. The grey matter on the dorsal surface is covered with ependyma.

The **upper border** is arched, rising higher at the centre than laterally, and the two crura cerebri emerge from it. The **lower border** is straight, and the sixth, seventh or facial, and eighth or auditory, nerves are met with at this border in the order named from within outwards.

Internal Structure of the Pons Varolii.—The pons is composed of a large ventral and a small dorsal part.

Ventral Part.—This portion consists of: (1) bundles of transverse fibres, (2) bundles of longitudinal fibres, and (3) a large amount of grey matter.

The **bundles of transverse fibres** intersect the bundles of longitudinal fibres, and on either side they are collected into the middle peduncle of the cerebellum, which enters the corresponding cerebellar hemisphere. Some of the transverse fibres arise in the cortex of the cerebellum as the axons of the cells of Purkinje, and these

terminate in the pons in arborizations around the cells of the *nucleus pontis*, mostly on the opposite side to that on which they arise. Other transverse fibres arise in the pons as the axons of the cells of the nucleus pontis on one side. They then cross to the other side, and enter the cerebellar hemisphere of that side, where they terminate in arborizations in the cortex. The fibres, therefore, of which the middle peduncle of the cerebellum is composed may be regarded as being of two kinds, namely, efferent and afferent. The efferent fibres arise in the cerebellar cortex and terminate in the pons, whilst the afferent fibres arise in the pons and terminate in the cerebellar cortex.

The **bundles of longitudinal fibres** are derived from the breaking up of the pyramids of the medulla oblongata as they sink into the pons. At the upper border of the pons they yre collected together and form the two crura cerebri. The longitudinal bundles which enter the pons from above are more numerous than those which leave it below in the pyramids, the explanation being that some fibres terminate in the pons in arborizations around the cells of the nucleus pontis.

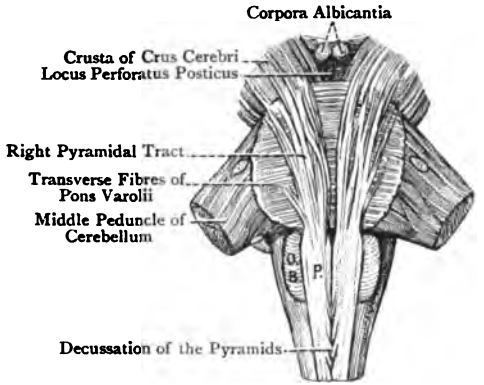


FIG. 549.—DISSECTION OF THE PONS VAROLII, SHOWING THE COURSE OF THE PYRAMIDAL TRACTS OF THE MEDULLA OBLONGATA (HIRSCHFELD AND LEVEILLÉ).

P, Right Pyramid; O.B., Right Olivary Body.

The **grey matter** of the pons, which is large in amount, occupies the intervals between the intersecting transverse and longitudinal bundles, and contains small multipolar nerve-cells. It is known as the *nucleus pontis*, and is continuous with the arcuate nuclei of the medulla oblongata.

Corpus Trapezoides. — This represents a group of transverse fibres which have no connection with the middle peduncles of the cerebellum. The group is situated in the lower part of the pons. Its fibres arise partly from the cells of the central or accessory nucleus of the cochlear division of the auditory nerve, and partly from those of the superior olivary nucleus. Some of the fibres end in the superior olivary nucleus. Others cross the median line to the opposite side and enter the lateral fillet, the fibres of which terminate in the inferior quadrigeminal body and internal geniculate body of that side.

Dorsal or **Tegmental Part of the Pons.**—This portion is divided

into two symmetrical halves by a median raphé, which is an upward continuation of that of the open part of the medulla oblongata. The dorsal part is principally composed of a prolongation of the formatio reticularis of the medulla. Inferiorly, in the region of the corpus trapezoides there are important tracts of nerve-fibres, and collections of grey matter from which important nerves arise. These will now be described in order from without

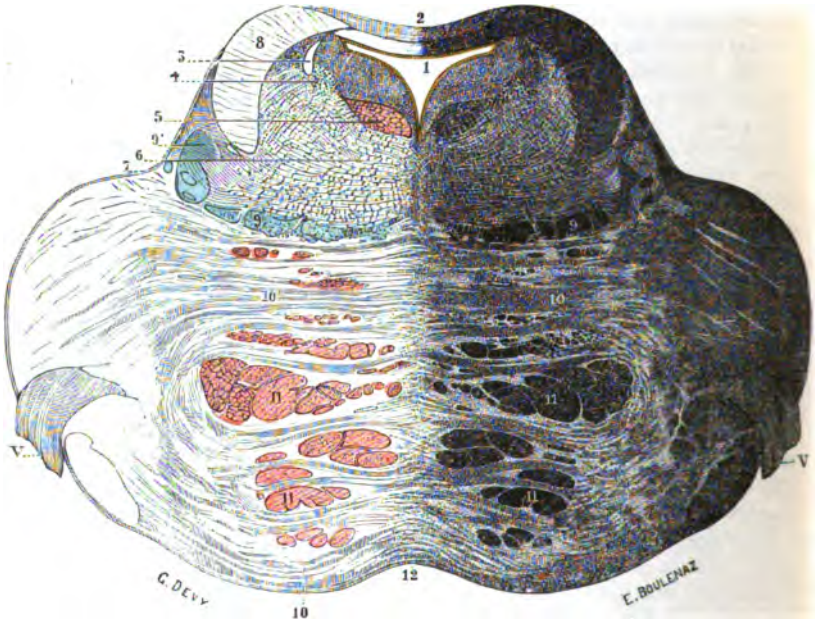


FIG. 550.—VERTICAL TRANSVERSE SECTION THROUGH THE UPPER PART OF THE PONS VAROLII (FROM L. TESTUT'S 'ANATOMIE HUMAINE,' AFTER STILLING).

1. Fourth Ventricle
2. Valve of Vieussens
3. Superior Root of Fifth Nerve
4. Nerve-cells which accompany this Root
5. Posterior Longitudinal Bundle
6. Formatio Reticularis
7. Lateral Fissure of Isthmus
8. Section of Superior Cerebellar Peduncle
9, 9'. Mesial and Lateral Portions of the Fillet
10, 10. Transverse Fibres of the Pons
11, 11. Longitudinal Fibres of the Pons
12. Raphé
V. Fifth Nerve

inwards on either side. (1) The fasciculi of the spinal or ascending root of the fifth nerve lie externally on the inner side of the restiform body, the vestibular root of the auditory nerve intervening between the two. (2) The nucleus of the facial nerve is next in order. It is deeply situated in the dorsal part of the pons in close proximity to the fibres of the corpus trapezoides, and behind the superior olivary nucleus. The fibres of the facial nerve, having

arisen from the cells of the facial nucleus, pass backwards and inwards towards the grey matter on the floor of the fourth ventricle. Here they are collected into one bundle which traverses the pons in a forward and outward direction on the outer side of the facial nucleus, to the place where the nerve makes its superficial appearance. (3) The superior olivary nucleus is situated internal to, but deeper than, the facial nucleus, and behind the fibres of the corpus trapezoides, some of which enter it, whilst others are derived from it. (4) The nucleus of the sixth nerve consists of a group of multipolar cells, which lie close beneath the floor of the fourth ventricle in the region of the upper part of the eminentia teres. The fasciculi of the nerve pass forwards and downwards to the lower border of the pons, where the nerve emerges. (5) The posterior longitudinal bundle and the fillet are internal to the nucleus of the sixth nerve, and they lie close to the median raphé. The posterior longitudinal bundle is posterior in position—that is to say, nearest the floor of the fourth ventricle—and it receives nerve-fibres from the nucleus of the sixth nerve.

Above the level of the corpus trapezoides the dorsal part of the pons also presents important structures. (1) The nuclei of the fifth nerve are two in number, motor and sensory. The **motor nucleus** is situated close to the lateral margin of the upper part of the floor of the fourth ventricle, where it lies near the dorsal surface of the pons. The **sensory nucleus** is situated on the outer side of the motor nucleus, and is more deeply placed. It is here joined from below by the fibres of the spinal or ascending root of the nerve. Above these two nuclei a descending tract of nerve-fibres makes its appearance close to the inner aspect of the superior peduncle of the cerebellum. These fibres constitute the descending root of the fifth nerve, and they join the motor part of the nerve. They arise from the lateral portion of the grey matter which surrounds the aqueduct of Sylvius. The roots of the fifth nerve traverse the ventral part of the pons, from which they emerge close to the middle peduncle of the cerebellum.

(2) The posterior longitudinal bundle is continued upwards through the upper portion of the dorsal part of the pons, and maintains its position close to the median raphé.

(3) The fillet is prolonged upwards, lying on the ventral aspect of the posterior longitudinal bundle, and it is now known as the **mesial fillet.**

(4) The **lateral fillet** derives its fibres largely from the corpus trapezoides, and it lies external to the mesial fillet.

(5) The nucleus of the lateral fillet is a small collection of grey matter, which lies between the mesial and lateral fillets. It is regarded as being continuous with the superior olivary nucleus.

(6) The superior peduncle of the cerebellum lies on the outer side of the floor of the fourth ventricle.

Development.—The pons Varolii is developed as a thickening of the ventral and lateral walls of the metencephalon, which is one of the divisions of the rhombencephalon.

3. The Cerebellum.

The cerebellum, or small brain, occupies the inferior occipital or cerebellar fossæ of the occipital bone. It lies beneath the posterior parts of the hemispheres of the cerebrum, from which it is separated by a septum of the dura mater, called the tentorium cerebelli, and it is posterior to the medulla oblongata and pons Varolii. It is composed of white and grey matter, the white matter being situated in the interior, where it constitutes the medullary substance, and the grey matter being spread over the surface as the cortex. In appearance it is laminated or foliated, the laminæ being separated from each other by parallel, slightly curved sulci. It is composed of two large lateral portions, called **hemispheres,** and a connecting median portion, termed the **vermis** ('worm') or **vermiform process,** these parts being much more distinctly demarcated below than above. It presents, in the median line, two notches, anterior and posterior. The **anterior notch,** which is wide, is known as the *incisura semilunaris*, and it contains the inferior pair of quadrigeminal bodies and the superior cerebellar peduncles. The **posterior notch** is narrow, and is occupied by the falx cerebelli. The most conspicuous sulcus of the cerebellum is the **great horizontal fissure,** which extends round the circumference, and passes for some distance into the interior. By means of this fissure the cerebellum is divided into two parts, upper and lower.

Upper Surface of the Cerebellum.—This surface presents in the median line the upper part of the vermis, known as the **superior vermis.** It extends from the incisura semilunaris to the posterior notch, and it forms a laminated elevation, which is higher in front than behind, the most prominent part being known as the *monticulus cerebelli*. On either side of the superior vermis the upper surface of each hemisphere inclines downwards to the circumference, and there is no distinct demarcation between it and the superior vermis.

The **superior vermis** is composed of five lobules, named, in order from before backwards, the lingula, central lobule, culmen monticuli, clivus monticuli, and folium cacuminis. The **lingula** is deeply placed, and consists of about four laminæ or folia, which lie over the superior medullary velum as it extends between the superior cerebellar peduncles. Its laminæ may be continued on either side over the superior cerebellar peduncle, and, when this is so, the prolongation is known as the **frenulum linguæ.**

The **central lobule** is of small size, and lies at the bottom of the incisura semilunaris. It is separated from the lingula by the precentral fissure, and from the culmen monticuli by the postcentral fissure.

The **culmen monticuli** forms the summit of the superior vermis. It is composed of several laminæ, and posteriorly is separated from the clivus by the preclival fissure.

The **clivus monticuli** represents the sloping part of the monticulus

cerebelli. It is situated behind the culmen monticuli, and is composed of several laminæ. Posteriorly it is separated from the folium cacuminis by the postclival fissure.

The **folium cacuminis** forms the posterior extremity of the superior vermis, and lies at the posterior notch, where it is placed above the great horizontal fissure.

The **upper surface of each hemisphere** is mapped out into lobules, which are continuous with the subdivisions of the superior vermis, with the exception of the lingula. These are called, in order from before backwards, the ala, anterior crescentic lobule, posterior crescentic lobule, and postero-superior lobule.

The *ala* is continuous with the central lobule, from which it is

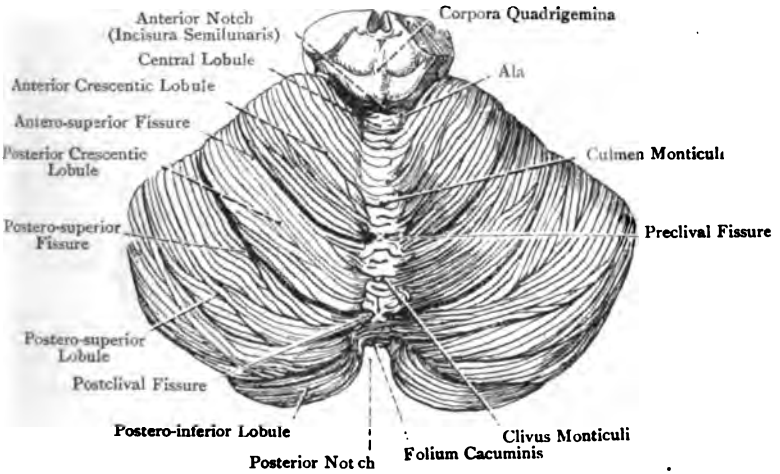


FIG. 551.—THE CEREBELLUM (SUPERIOR VIEW).

prolonged for a limited distance round the anterior part of the hemisphere in the region of the incisura semilunaris.

The *anterior crescentic lobule* is continuous with the culmen monticuli, and represents the anterior subdivision of the upper surface of the cerebellar hemisphere. It is limited posteriorly by a curved sulcus, called the *antero-superior fissure*, which is continuous with the *preclival fissure*, and opens at the circumference into the great horizontal fissure. The right and left anterior crescentic lobules, together with the culmen monticuli, form the **lobus culminis.**

The *posterior crescentic lobule* is continuous with the clivus monticuli. It is limited in front by the *antero-superior fissure*, and behind by the *postero-superior fissure*, the latter being continuous with the *postclival fissure*, and opening at the circumference into the great horizontal fissure. The right and left posterior

crescentic lobules, together with the clivus monticuli, form the **lobus clivi.**

The *postero-superior lobule* (superior semilunar lobule) corresponds to, but is much more extensive than, the folium cacuminis. It is limited in front by the postero-superior fissure, and behind by the great horizontal fissure. The right and left postero-superior lobules, together with the folium cacuminis, form the **lobus cacuminis.**

Under Surface of the Cerebellum.—The under surface presents in the median line a deep groove, called the **vallecula,** which is continuous behind with the posterior notch. Anteriorly it lodges the medulla oblongata, and lying in the bottom of it there is the lower part of the vermis, which is known as the **inferior vermis.**

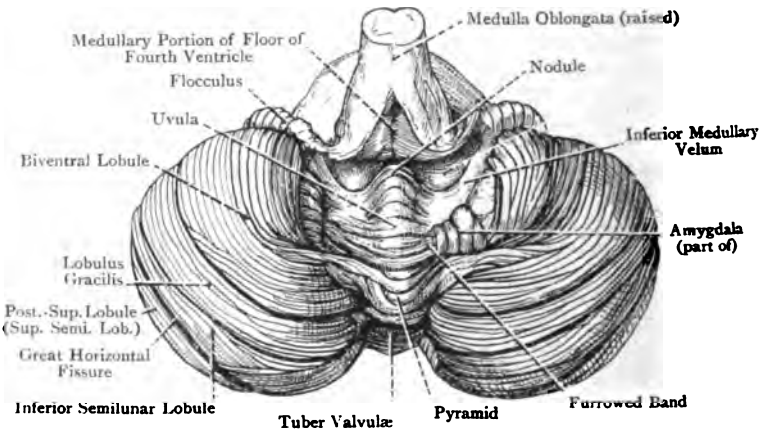


FIG. 552.—THE CEREBELLUM (INFERIOR VIEW).

(The Inferior Semilunar Lobule and the Lobulus Gracilis together constitute the Postero-inferior Lobule).

The vallecula separates the two cerebellar hemispheres from each other, and the inferior vermis is separated on either side from the corresponding hemisphere by a furrow called the *sulcus vallecula*. The under surfaces of the hemispheres are markedly convex, and are received into the inferior occipital or cerebellar fossæ of the occipital bone.

The **inferior vermis** is composed of four lobules, named, in order from behind forwards, tuber valvulæ, pyramid, uvula, and nodule.

The **tuber valvulæ** (tuber posticum) forms the posterior part of the inferior vermis, and is composed of several laminæ. On either side it is prolonged into the corresponding hemisphere, and becomes continuous with the postero-inferior lobule. It is the only part of the inferior vermis which is prolonged into the cerebellar hemispheres.

The **pyramid** is situated in front of the tuber valvulæ. It presents about four laminæ, and is separated by deep sulci from the tuber valvulæ behind and the uvula in front, whilst on either side it is separated from the cerebellar hemisphere by the sulcus valleculæ. Laterally it is connected with the biventral lobule of the hemisphere by means of a faint ridge, but this lies low in the sulcus valleculæ as it crosses it.

The **uvula** is situated in front of the pyramid, and between the amygdalæ or tonsils of the hemispheres. It is triangular, the base being directed backwards, and it consists of several laminæ. It is separated on either side from the hemisphere by the sulcus valleculæ. Laterally its narrow part is connected with the amygdala by a ridge of grey matter, but this lies low in the sulcus

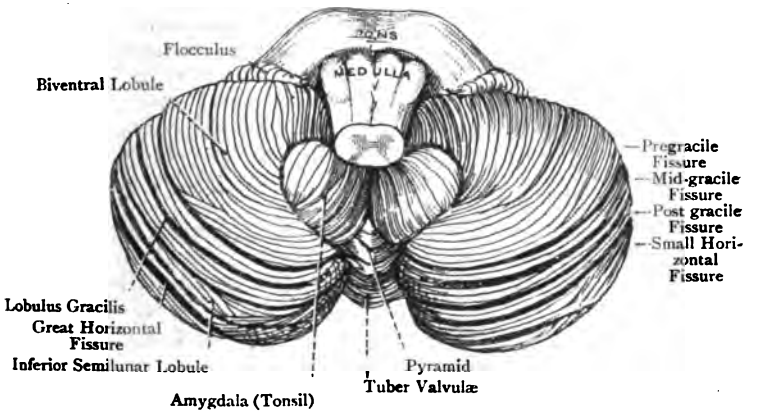


FIG. 553.—THE CEREBELLUM (INFERIOR VIEW).

(The Inferior Semilunar Lobule and the Lobulus Gracilis constitute the Postero-inferior Lobule).

valleculæ as it crosses it. This ridge is notched at intervals, and is called the **furrowed band.**

The **nodule** forms the anterior part of the inferior vermis, and is composed of several laminæ, which are largely concealed by the uvula. It is connected on either side with the flocculus by a thin semilunar band of white matter, which is the lateral portion of the **inferior medullary velum.**

The **fissures** of the inferior vermis are three in number, as follows: *postpyramidal*, between the pyramid and the tuber valvulæ; *prepyramidal*, between the pyramid and the uvula; and *postnodular*, between the nodule and the uvula.

The **under surface of each hemisphere** is mapped out into four lobules, which are called, from behind forwards, the postero-inferior lobule, the biventral lobule, the amygdala, and the flocculus.

The **postero-inferior lobule** is situated at the back part of the under surface of the hemisphere. It is divided into four curved parts by three curved fissures. The anterior two parts are known as the *lobulus gracilis*, and the posterior two as the *inferior semilunar lobule*. The right and left postero-inferior lobules, together with the tuber valvulæ, form the **lobus tuberis.**

The **biventral lobule** is composed of curved laminæ, and is somewhat triangular. The pointed end is directed backwards and inwards, and it is connected with the pyramid by a faint ridge, which, as stated, lies low in the sulcus valleculæ. The base is directed forwards towards the flocculus. The lobulus gracilis lies external to it, and the amygdala is on its inner side. The biventral lobule is divided by a sulcus into two portions, outer and inner; hence the name 'biventral.' The right and left biventral lobules, together with the pyramid, form the **lobus pyramidis.**

The **amygdala** (tonsil) forms a conspicuous prominence between the uvula and the biventral lobule. It is situated in a depression of the vallecula, which is known as the *nidus avis* ('bird's nest'), and its direction is almost sagittal. It is connected with the narrow part of the uvula by the furrowed band, which, as stated, lies low in the sulcus valleculæ. The right and left amygdalæ, together with the uvula, form the **lobus uvulæ.**

The **flocculus** (subpeduncular lobule) is a small irregular lobule which is situated between the front of the biventral lobule and the middle peduncle of the cerebellum. Internally it is connected with the nodule by the lateral portion of the inferior medullary velum. The right and left flocculi, together with the nodule, form the **lobus nodull.**

The fissures of the under surface of each hemisphere are as follows: (1) a continuation of the postnodular sulcus, between the biventral lobule and the flocculus; (2) a continuation of the prepyramidal sulcus, between the amygdala and the biventral lobule; (3) the pregracile, or anterior arcuate, sulcus, between the biventral lobule and the lobulus gracilis; (4) the mid-gracile, or middle arcuate sulcus, within the lobulus gracilis; (5) the postgracile, or posterior arcuate, sulcus, between the lobulus gracilis and the inferior semilunar lobule; and (6) the small horizontal sulcus within the inferior semilunar lobule.

Peduncles of the Cerebellum.—The peduncles are three in number on either side, namely, superior, middle, and inferior, and they are composed of fibres which enter, or emerge from, the central white medullary substance.

The **superior peduncles** are composed of efferent fibres, and are at first concealed from view by the upper or anterior portions of the hemispheres. After emerging from the hemispheres they pass upwards on the lateral aspects of the dorsal surface of the pons Varolii in a converging manner towards the quadrigeminal bodies. They form the lateral boundaries of the upper part of the floor of the fourth ventricle, and by their convergence they project

slightly over that part of the ventricle, so as to take part in its roof. The superior medullary velum extends between the two peduncles, and closes the interval between them. On reaching the inferior pair of quadrigeminal bodies the two peduncles pass beneath them and enter the mesencephalon, where their course will be subsequently described (see p. 1331). The most of the fibres of each superior peduncle are derived from the corresponding nucleus dentatus, but a few come from the grey matter of the cerebellar cortex.

The **middle peduncles** are of large size, and re aformed by the transverse fibres of the pons Varolii, these being gathered together on either side into a large bundle, which passes backwards and outwards into the white central medullary substance of the corresponding hemisphere. The fibres of each middle peduncle are both afferent and efferent. The afferent fibres arise in the pons from the cells of the nucleus pontis of the opposite side, and terminate in arborizations around the cells of the cerebellar cortex. The efferent fibres arise from the cells of the cerebellar cortex of the same side, and terminate in arborizations around the cells of the nucleus pontis, mostly on the opposite side.

The **inferior peduncles** constitute the restiform bodies of the medulla oblongata. Each restiform body after leaving the medulla lies for a short distance on the dorsal aspect of the pons Varolii, and thereafter enters the corresponding cerebellar hemisphere. The inferior peduncles are composed of both afferent and efferent fibres. The afferent fibres are chiefly represented by those of the direct cerebellar tracts. They are regarded as terminating in the cortex of the superior vermis, on both sides of the median line, but chiefly on the opposite side. The efferent fibres are mostly represented by the cerebello-olivary fibres. They probably arise in the cortex of the cerebellar hemisphere and superior vermis, and in the nucleus dentatus. For their termination, see p. 1265.

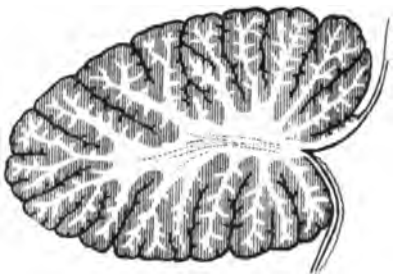


FIG. 554.—SAGITTAL SECTION OF A HEMISPHERE OF THE CEREBELLUM, SHOWING THE ARBOR VITÆ.

White and Grey Matter of the Cerebellum. — In the hemispheres and vermis the white matter is situated in the centre as the medulla, and the grey matter is disposed superficially as the cortex. The white matter in the interior of the vermis is known as the *corpus trapezoides*. When sagittal sections of a hemisphere are made the mass of white matter in the centre is seen to send offshoots into the lobules. From the sides of these offshoots secondary processes are given off, and these in turn furnish tertiary processes, the white

matter in all cases being covered by grey matter. When the section is made across the direction of the laminæ or folia the appearance presented is like the trunk and branches of a tree : hence the name *arbor vitæ cerebelli* is applied to it.

Nuclei.—The **corpus dentatum** is a collection of grey matter which is situated within the white matter of each hemisphere, and it is similar to the inferior olivary nucleus in the olivary body of the medulla oblongata. It is composed of a wavy grey lamina, disposed in the form of a capsule, which encloses white matter. The capsule presents an opening or *hilum* at its upper and inner part, and through this a large number of the fibres of the superior cerebellar peduncle emerge from the interior.

There are three other nuclei on each side, as follows : (1) the **nucleus emboliformis,** close to the inner side of the hilum of the corpus dentatum ; (2) the **nucleus globosus,** internal to the preceding ; and (3) the **nucleus fastigii,** or roof-nucleus, situated in the corpus trapezoides of the vermis, close to the median line, and contiguous to its fellow of the opposite side.

Commissural and Association Fibres.—The **commissural fibres** pass from the white matter of one hemisphere to that of the opposite hemisphere. They traverse the corpus trapezoides of the vermis in two sets, superior and inferior. The **association fibres** are confined to each side, and they connect adjacent laminæ, passing across the bottom of the fissures which separate them.

Medullary Vela.—These are thin laminæ or curtains of white matter, and are two in number, superior and inferior.

The **superior medullary velum,** or *valve of Vieussens*, is continuous with the corpus trapezoides or white matter of the vermis. It extends between the converging superior cerebellar peduncles, bridging over the interval between them, and becoming continuous with their inner margins. Superiorly it extends to the inferior pair of quadrigeminal bodies, and inferiorly it passes into the corpus trapezoides or white matter of the vermis. It forms a large portion of the roof of the upper part of the fourth ventricle, and its dorsal surface supports the lingula of the superior vermis. From the upper part of the superior medullary velum a band of white fibres, called the *frenulum veli*, passes to the lower part of the median longitudinal groove which separates the lateral pairs of quadrigeminal bodies. Immediately below the inferior pair of quadrigeminal bodies the fourth pair of cranial nerves emerge from the superior medullary velum, on either side of the frenulum veli. The tract of Gowers, after having traversed the formatio reticularis of the medulla oblongata and the dorsal part of the pons Varolii, passes into the superior medullary velum, and then descends in the superior cerebellar peduncle to the cerebellum.

The **inferior medullary velum** is a thin lamina of white matter which is continuous with the white matter of the cerebellum above the nodule of the inferior vermis. On either side of the nodule it

extends outwards to the flocculus in the form of a delicate semi-lunar band, and it forms a part of the roof of the fourth ventricle in succession to the superior medullary velum.

Minute Structure of the Cerebellar Laminæ.—Each lamina or folium of the cerebellum consists of (1) a central part or core of white matter, which is an offshoot from the white medullary substance, and (2) an external part or cortex of grey matter.

Grey Cortex.—The **grey cortex** is composed of two layers, an outer **molecular layer,** and an inner **granular layer.** Between these two layers there is a stratum of characteristic large cells, called the cells or corpuscles of Purkinje.

The **cells of Purkinje** are pyriform or flask-shaped, and are situated, as just stated, between the molecular and granular layers. The narrow or superficial end of each cell projects into

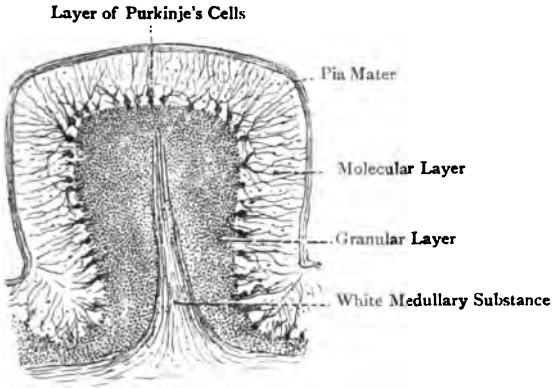


FIG. 555.—STRUCTURE OF A LAMINA OF THE CEREBELLUM (HIGHLY MAGNIFIED).

the molecular layer, and the broad or deep end rests on the granular layer. From the broad or deep end of each cell a single axon passes off, which enters the granular layer, where it soon becomes medullated, and then forms a nerve-fibre of the white medullary substance. The axon of Purkinje's cell gives off a few collateral recurrent branches, some of which end in the granular layer, whilst others enter the molecular layer. From the narrow or superficial end of each cell numerous dendrites are given off. These are at first gathered into one, or it may be two, stems, and after entering the molecular layer these divide and subdivide into a great many ramifying branches, which impart a characteristic arborescent appearance to the arrangement of dendrites. The branches of these dendrites extend through the molecular layer to the surface.

The **molecular layer** consists of fibres and cells. The **fibres** are

derived from the following sources: (1) the dendrites and the collaterals of the axons of the cells of Purkinje; (2) the dendrites and the axons of the cells in the molecular layer; (3) the axons of the granule-cells in the granular layer; (4) the fibres of Bergmann, derived from the glia-cells in the granular layer, which pass outwards to the surface; and (5) fibres from the white medullary substance of the cerebellum. The **cells** of the molecular layer are arranged in two sets, outer and inner. Each of the outer cells is furnished with an axon and dendrites, the latter branching freely. The inner cells are known as *basket-cells*, and they lie in the vicinity of Purkinje's cells. Each of them is furnished with an axon and dendrites. The axons run transversely between the dendrites of Purkinje's cells, and in their course give off collaterals, which break up into numerous terminal ramifications, arranged in the form of 'baskets,' in which the cells of Purkinje lie.

The **granular layer** is composed of a great number of small granule- or nerve-cells and fibres. The **granule-cells** impart to it a reddish-brown colour; hence the name *rust-coloured layer*. The cells are provided with axons and dendrites. The ramifications of the dendrites terminate in tufts which are closely related to contiguous cells. The axon of each cell enters the molecular layer, in which it passes towards the surface. On approaching the surface each axon divides into two branches, which diverge and pass horizontally between the terminal ramifications of the dendrites of Purkinje's cells, with which they come into close contact. In addition to the small granule-cells there are other large stellate cells, situated in the outer part of the granular layer, near the cells of Purkinje. These are regarded as glia-cells, and they are provided with long branching dendrites. The dendrites enter the molecular layer, in which they extend to the surface as the fibres of Bergmann. At the surface these fibres end in conical enlargements, the broad ends being directed towards the surface, and in this manner a kind of membrana limitans externa is constructed. The axons of the stellate or glia-cells are confined to the granular layer, and are remarkable for their ramifications. These cells may be regarded as belonging to the neuroglia of the cerebellum. The **fibres** of the granular layer are derived from the following sources: (1) the axons of the cells of Purkinje; (2) the moss-fibres of Cajal; and (3) fibres on their way from the white medullary substance to the deep part of the molecular layer.

White Matter of the Cerebellum.—The white matter is composed of medullated nerve-fibres, arranged in bundles, which enter the grey cortex. They terminate in one of three ways. (1) Some become the axons of the cells of Purkinje. (2) Others pass through the granular layer into the molecular layer, where they break up into branches which are closely related to the more deeply placed dendrites of Purkinje's cells. (3) A third set terminate in the granular layer, where they divide into branches which present

'moss-like appendages,' from which circumstance they are known as the *moss-fibres* (Cajal).

Development.—The cerebellum is developed as a thickening of the dorsal wall of the metencephalon, which is one of the divisions of the rhombencephalon.

4. The Fourth Ventricle.

The fourth ventricle is the space between the medulla oblongata and pons Varolii in front and the vallecula of the cerebellum behind. Inferiorly it is continuous with the central canal of the spinal cord, and superiorly with the aqueduct of Sylvius, by which it communicates with the third ventricle. The floor is rhomboidal or diamond-shaped. The lower angle is called the *calamus scriptorius*, from its resemblance to the point of a writing-pen, and it is at this angle where the central canal of the spinal cord, after traversing the lower or closed part of the medulla oblongata, opens into it. The upper angle is continued into the aqueduct of Sylvius. The ventricle is widest opposite the middle peduncles of the cerebellum, and its lateral angles correspond with this level. In each of these situations it is prolonged outwards round the upper part of the restiform body, this prolongation being called the *lateral recess*. The ventricle presents a dorsal wall or roof and a ventral wall or floor.

Roof of the Fourth Ventricle. — The *upper part* of the roof is formed by the superior medullary velum, as it extends between the converging superior peduncles of the cerebellum, and also to a certain extent by these peduncles, which slightly overhang the space. The *middle part* of the roof is formed by the corpus trapezoides, or white matter of the vermis, into which a portion of the roof extends in a pointed manner. The *lower part* of the roof is formed superiorly by the inferior medullary velum, and below this by a single layer of flattened epithelium, covered by pia mater, the latter being called the *tela choroidea inferior*. The epithelium of the roof becomes continuous with that of the floor, but before this takes place three laminæ of white matter project over it for a short distance, namely, the obex and the two ligulæ, right and left. The **obex** is situated at the lower angle of the floor, where it lies behind the upper opening of the central canal, and covers the point of the calamus scriptorius. The **ligula,** or **tænia,** on either side projects over the epithelium of the roof for a short distance. Externally it is connected with the following structures, from below upwards: the clava, the cuneate tubercle, and the restiform body. Superiorly it passes outwards on the outer aspect of the restiform body, and it here forms the lower boundary of the lateral recess of the ventricle.

Openings in the Roof.—The epithelium and tela choroidea inferior present three openings, one being in the median line and the other two being placed one on each side. The median opening is

situated a little above the calamus scriptorius, and is called the **foramen of Magendie.** The lateral openings are situated one in the roof of each lateral recess of the ventricle, and are known as the **foramina of Kay and Retzius.** By means of these three openings the cavity of the fourth ventricle communicates with the subarachnoid space.

Choroid Plexuses of the Fourth Ventricle.—These are two in number, and are inflexions of the tela choroidea inferior (pia mater). They carry with them the roof-epithelium, and are disposed somewhat thus, ⅂ ⅁. The vertical portions extend upwrds from the foramen of Magendie, lying near the median line, and the transverse portions extend outwards, each projecting into the corresponding lateral recess, but covered by epithelium.

Summary of the Roof.—From above downwards the roof is formed by (1) the superior medullary velum, and superior peduncles of the cerebellum; (2) the corpus trapezoides or white matter of the vermis; (3) the inferior medullary velum; and (4) epithelium, covered by pia mater, the latter being known as the tela choroidea inferior. The laminæ of white matter which project over the roof are the obex in the median line and the two ligulæ, one at either side. The openings in the roof are the foramen of Magendie, and the foramina of Kay and Retzius. The choroid plexuses are two in number, and are inflexions of the tela choroidea inferior (pia mater), which carry the roof-epithelium before them.

Floor of the Fourth Ventricle.—The floor or ventral wall (*fossa rhomboidalis*) is formed in its *lower part* by the dorsal surface of the upper or open part of the medulla oblongata, and in its *upper part* by the dorsal surface of the pons Varolii. It is rhomboidal or diamond-shaped, and is widest opposite the middle peduncles of the cerebellum. The lower pointed portion, between the two clavæ of the medulla, is, as stated, called the *calamus scriptorius*. The entire floor is covered by a thick layer of grey matter, continuous with that which surrounds the central canal of the spinal cord, and of the lower or closed part of the medulla. This grey layer is covered by ependyma (epithelium), the ependymal cells being continuous with those which line the central canal. For convenience the floor is divided into two portions, namely, lower or medullary and upper or pontine.

Lateral Boundaries.—The **lower** or **medullary portion** is bounded laterally by (1) the clava, (2) the cuneate tubercle, and (3) the restiform body, in this order from below upwards. The **upper** or **pontine portion** is bounded laterally by the superior peduncle of the cerebellum.

The floor is traversed in the median line by a slight longitudinal groove, which divides it into two symmetrical halves. On either side of this groove the floor is crossed towards its centre by bundles of fibres, disposed transversely, called **striæ acusticæ.** These fibres apparently emerge from the median groove, and pass outwards over the restiform body. They subdivide each half of the floor into two portions, upper and lower.

Lower Portion.—This belongs to the medullary area of the floor. Immediately below the striæ acusticæ there is a small triangular depression, called the **fovea inferior.** Its apex is directed towards the striæ, and the lateral angles of its base are prolonged into grooves. The inner groove passes, in a curved manner, towards the point of the calamus scriptorius, and the outer groove passes downwards and outwards to the lateral boundary. Between these two diverging grooves there is a triangular area, called the **trigonum vagi.** Its apex is at the fovea inferior, and its base is directed downwards and outwards. It has a dark colour, and from this circumstance is known as the *ala cinerea.* It contains the nuclei

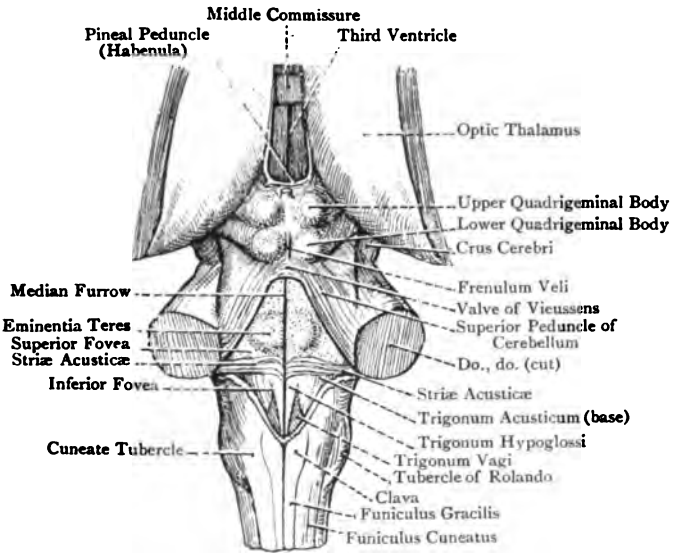


FIG. 556.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS.

of the vagus and glosso-pharyngeal nerves, the latter being the higher of the two. A second triangular area is situated between the median longitudinal groove on the one hand and the fovea inferior and the inner of the two grooves prolonged from its base on the other hand. This area is called the **trigonum hypoglossi,** and is slightly elevated. Its base is directed upwards towards the striæ acusticæ, and its apex looks downwards towards the calamus scriptorius. It contains the nucleus of the hypoglossal nerve. There is still another triangular area, called the **trigonum acusticum.** It is situated between the lateral boundary on the one hand and the fovea inferior and the outer of the two grooves prolonged from its base on the other hand. Its base is directed upwards, and is continued into a prominence, called the **tuber-**

culum acusticum, over which the striæ acusticæ pass. The trigonum acusticum and tuberculum acusticum represent the *area acustica*, which contains the chief nucleus of the vestibular division of the auditory nerve.

Upper Portion.—The upper portion is situated above the striæ acusticæ, and belongs to the pontine part of the floor. It presents, in line with the fovea inferior, a slight depression, called the **fovea superior.** Between this fovea and the median groove there is a well-marked prominence, called the **eminentia teres.** This is continued inferiorly into the trigonum hypoglossi, and superiorly it can be traced as far as the opening of the aqueduct of Sylvius. Below and external to the fovea superior there is a prominence, produced by

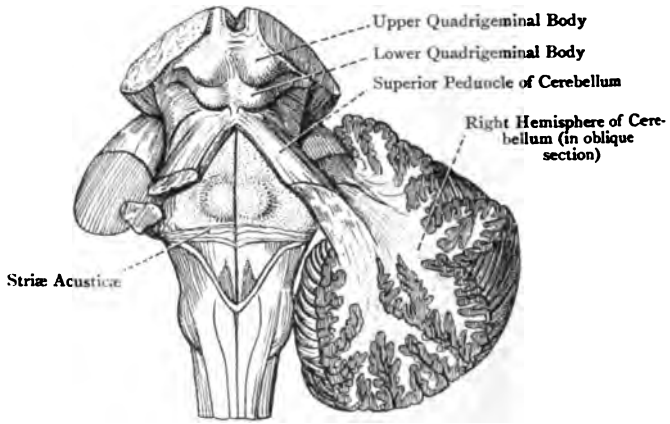


FIG. 557.—THE FOURTH VENTRICLE AND RIGHT HEMISPHERE OF THE CEREBELLUM (IN SECTION) (HIRSCHFELD AND LEVEILLÉ).

the tuberculum acusticum, which extends upwards in this situation. Above the fovea superior, and extending upwards from it to the opening of the aqueduct of Sylvius, there is a slight depression, called the **locus cæruleus,** from its bluish colour. This colour is due to a group of pigmented nerve-cells, known as the **substantia ferruginea.**

Summary of the Floor of the Fourth Ventricle—Lower or **Medullary Portion.**—Each half presents (1) the fovea inferior, (2) the trigonum vagi (ala cinerea), (3) the trigonum hypoglossi, and (4) the trigonum acusticum. **Upper** or **Pontine Portion.**—Each half presents (1) the fovea superior, (2) the eminentia teres, produced by the fasciculus teres, and (3) the locus cæruleus, due to the substantia ferruginea.

Development.—The upper or pontine part of the fourth ventricle is developed from the metencephalon; and the lower or medullary (bulbar) part is developed from the myelencephalon.

TELENCEPHALON.

Cerebral Hemispheres.

The cerebral hemispheres are two in number, right and left. Each is semi-ovoid, and presents two extremities and three surfaces.

The **extremities** are anterior and posterior. The **anterior extremity** is thick and round, and its most projecting part is called

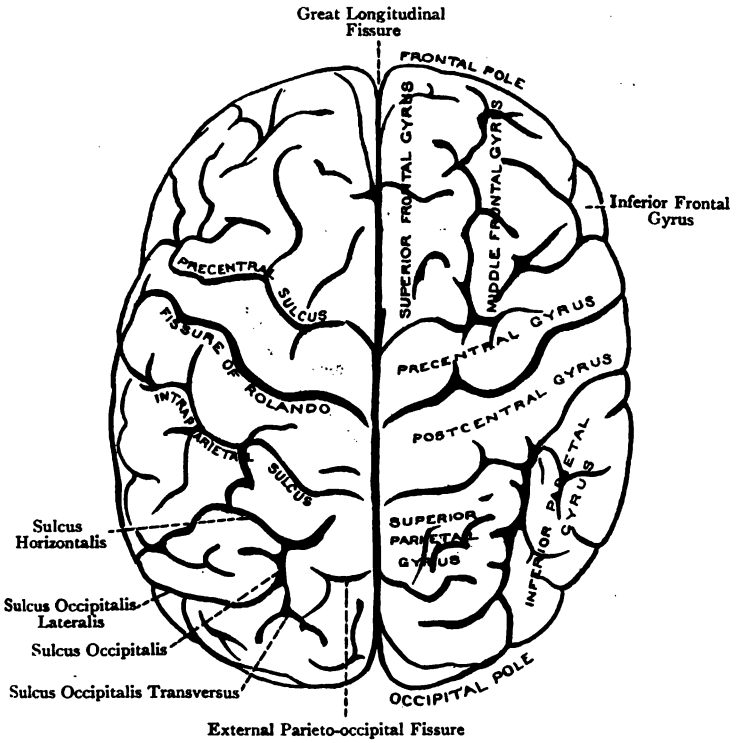


FIG. 558.—THE CEREBRAL HEMISPHERES (SUPERIOR VIEW).

the **frontal pole.** The **posterior extremity** is narrow and pointed, and its most projecting part is called the **occipital pole.** The **surfaces** are external, internal, and inferior. The **external surface** is convex, in adaptation to the concavity of the cranial vault. The **internal surface** is flat and vertical, and it forms the lateral boundary of the great longitudinal fissure. For the most part it is in contact with the falx cerebri. The **inferior surface** is irregular, being adapted to the corresponding lateral divisions of the anterior and middle fossæ of the interior of the base of the skull and the upper

surface of the tentorium cerebelli. It is crossed transversely by a deep cleft, representing the stem of the fissure of Sylvius. The portion in front of this fissure is known as the *orbital area*, and is concave, in adaptation to the convexity of the orbital plate of the frontal bone, upon which it rests. The extensive portion behind the stem of the Sylvian fissure is known as the *tentorial area*, and is prominent and arched. Its anterior portion is received into the lateral division of the middle cranial fossa, and its posterior portion rests upon the tentorium cerebelli.

The **borders** of each hemisphere are four in number, namely, supero-mesial, infero-lateral, superciliary, and internal occipital. The **supero-mesial border** separates the external from the internal surface. The **infero-lateral border** separates the external surface from the tentorial area of the inferior surface. The **superciliary** border separates the front part of the external surface from the orbital area of the inferior surface. The **internal occipital border** separates the internal surface from the tentorial area of the inferior surface, and it extends from the occipital pole to the splenium of the corpus callosum.

The exterior of each hemisphere is broken up into tortuous eminences, called **gyri** or **convolutions,** and these are separated from each other by clefts, called **sulci** or **fissures.** The exterior is composed of grey matter, which is spoken of as the **cerebral cortex,** and the interior is occupied by white matter, which forms the **medullary centre.** The breaking up of the hemispheres into gyri, with the intervening sulci, greatly increases the amount of cerebral cortex and, to a proportionate extent, of pia mater.

The **fissures** are of two kinds, complete and incomplete. The **complete fissures** are produced by invaginations of the wall of each cerebral vesicle; and the **incomplete fissures** are due to the growth of the gyri.

Each hemisphere presents six principal fissures, called interlobar fissures, and by means of these it is divided into six lobes. The fissures and lobes are as follows :

Interlobar Fissures.	Lobes.
1. Fissure of Sylvius.	1. Frontal.
2. Fissure of Rolando.	2. Parietal.
3. Parieto-occipital.	3. Occipital.
4. Calloso-marginal.	4. Temporal.
5. Collateral.	5. Island of Reil or Insula.
6. Circular or Limiting.	6. Limbic.

Interlobar Fissures.—The **fissure of Sylvius,** which is the first fissure to appear in the course of development, commences on the inferior surface of the hemisphere at the locus perforatus anticus in a depression, called the *vallecula Sylvii*. From this point it passes horizontally outwards to the *Sylvian point* on the external surface of the hemisphere, where it divides into three diverging branches. It is a deep cleft, which is overhung posteriorly by the front part of the temporal lobe, and it separates the orbital surface of the

frontal lobe from the temporal lobe. The posterior or Sylvian border of the small wing of the sphenoid bone faces the fissure, which lodges the middle cerebral artery. The limbs into which the fissure divides at the Sylvian point are, as stated, three in number, namely, anterior horizontal, anterior ascending, and posterior horizontal. The *anterior horizontal limb* passes forwards into the frontal lobe, its length being about ¾ inch. The *anterior ascending limb* passes upwards and slightly forwards into the frontal lobe for about 1 inch, but its length is variable. The *posterior horizontal limb* is the longest and most conspicuous. It passes backwards on the external surface of the hemisphere for at least 2 inches, having portions of the frontal and parietal lobes above it, and the temporal lobe below it. Finally it turns upwards into the parietal lobe for a very short distance.

The **fissure of Rolando,** also known as the *central sulcus*, commences at the supero-mesial border of the hemisphere, a little behind its mid-point, and terminates above the centre of the posterior horizontal limb of the fissure of Sylvius. It does not usually open into this limb, but may do so. Superiorly the fissure in most cases intersects the supero-mesial border to reach the internal surface of the hemisphere, upon which it passes backwards for a very short distance. The direction of the fissure of Rolando is irregularly downwards and forwards over the external surface of the hemisphere, and it separates the frontal from the parietal lobe. It describes two bends. The *upper genu* has its concavity directed forwards, and is situated about the junction of the upper and middle thirds of the fissure. The *lower genu* has its concavity directed backwards, and is situated on a more anterior plane than the upper genu. Below the lower genu the direction of the fissure is almost vertical, with a slight inclination backwards.

The **parieto-occipital fissure** is situated about 2 inches behind the upper end of the fissure of Rolando, and it separates the parietal from the occipital lobe. It is composed of two limbs, external and internal, which are continuous with each other at the supero-mesial border of the hemisphere, where they form a right angle. The **external limb** is situated on the external surface of the hemisphere, upon which it passes transversely outwards for about ¾ inch, when it is arrested by the convolution which connects the parietal and occipital lobes. The **internal limb** appears as a deep, almost vertical, cleft on the internal surface of the hemisphere, which opens into the calcarine fissure a short distance behind the splenium of the corpus callosum.

The **calloso-marginal fissure** is situated on the internal surface of the hemisphere. It commences below the rostrum of the corpus callosum, contiguous to the locus perforatus anticus, and, bending round the genu, it passes backwards above the corpus callosum, from which it is separated by the callosal gyrus. At a point a little behind the centre of the internal surface of the hemisphere it turns upwards and terminates at the supero-mesial border, a short distance

behind the upper end of the fissure of Rolando. The callosomarginal fissure lies between the frontal and limbic lobes, the marginal gyrus being above it and the callosal gyrus below it.

The **collateral fissure** is situated on the inferior surface of the hemisphere. It commences near the occipital pole, and extends forwards to near the temporal pole. Posteriorly it has the calcarine fissure above, and in line with, it, and anteriorly it has the hippocampal gyrus on its mesial side. It separates the temporal lobe from the hippocampal portion of the limbic lobe. The middle

FIG. 559. — THE LEFT CEREBRAL HEMISPHERE (SUPERIOR SURFACE).

Red = Frontal Lobe. Orange = Parietal Lobe. Blue = Occipital Lobe.

portion of the collateral fissure gives rise to the eminentia collateralis in the floor of the lateral ventricle.

The **circular** or **limiting fissure** is situated deeply in the anterior part of the posterior horizontal limb of the fissure of Sylvius. It almost surrounds the convolutions which constitute the island of Reil or insula, and is composed of three parts—superior, inferior, and anterior. The *superior part* separates the insula from the frontal and parietal lobes, the *inferior part* separates it from the temporal lobe, and the *anterior part* separates it from the frontal lobe. The circuar fissure is deficient in the region of the apex of the insula.

Lobes of the Cerebral Hemisphere — Frontal Lobe.—This is of

large size. On the *external surface* of the hemisphere it is bounded behind by the fissure of Rolando, and below by the posterior horizontal limb of the fissure of Sylvius. On the *inferior surface* it is bounded behind by the stem of the fissure of Sylvius. On the internal surface it is bounded by the calloso-marginal fissure. The frontal lobe has three surfaces—external, inferior, and internal.

External Surface.—This surface presents three principal sulci, namely, precentral, superior frontal, and inferior frontal.

The **precentral sulcus** is more or less parallel to the fissure of Rolando, the ascending frontal or precentral gyrus intervening between the two. It may be a single fissure, but it more frequently consists of two parts, superior and inferior. The *superior part* is usually joined above by the superior frontal sulcus. The *inferior part* passes superiorly into the middle frontal gyrus for a short distance in a forward and upward direction.

FIG. 560.—THE RIGHT CEREBRAL AND CEREBELLAR HEMISPHERES (EXTERNAL SURFACE).

Red = Frontal Lobe. Blue = Occipital Lobe.
Orange = Parietal Lobe. Green = Temporal Lobe.
Purple = Cerebellar Hemisphere.

The **superior** and **inferior frontal sulci** extend forwards from the precentral sulcus.

The **gyri** of the external surface are as follows : ascending frontal, superior frontal, middle frontal, and inferior frontal.

The **ascending frontal** or **precentral gyrus** is bounded behind by the fissure of Rolando or central sulcus, and in front by the superior and inferior parts of the precentral sulcus. It extends from the supero-mesial border of the hemisphere to a little behind the Sylvian point, which corresponds to the place where the stem of the fissure of Sylvius appears on the external surface of the hemisphere, and divides into its three branches. Below the lower end of the fissure of Rolando it is, as a rule, connected with the ascending parietal or postcentral gyrus by an annectant gyrus.

The **superior** or *first*, **middle** or *second*, and **inferior** or *third* **frontal gyri** are arranged in tiers, which are disposed antero-posteriorly, the first and second being usually each subdivided, so as to make five tiers in all. They are separated from the ascending frontal or precentral gyrus by the superior and inferior parts of the precentral sulcus.

The **superior frontal gyrus** is narrow, and lies between the superomesial border of the hemisphere and the superior frontal sulcus. It is continuous with the marginal gyrus on the internal surface of

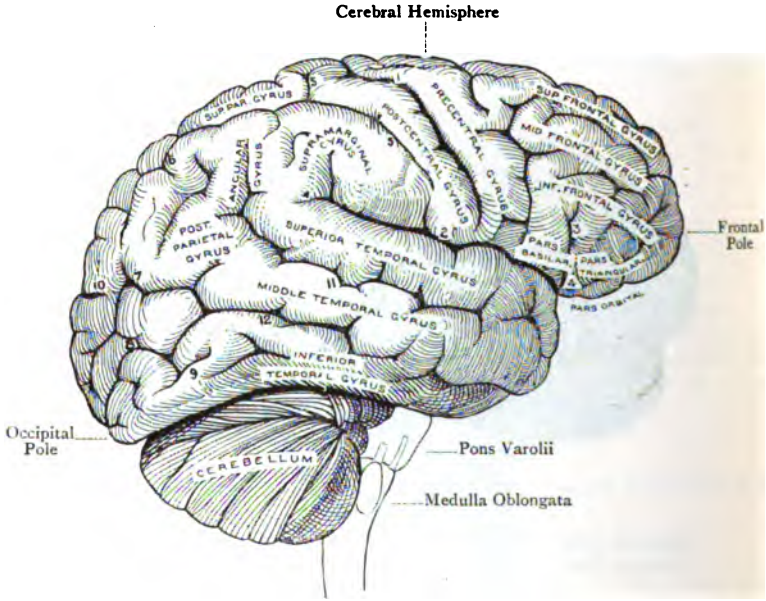


FIG. 561.—THE ENCEPHALON (RIGHT LATERAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

the hemisphere, and is partially broken up into two parts, upper and lower.

The **middle frontal gyrus,** which is broad, lies between the superior and inferior frontal sulci, and is usually connected with the ascending frontal or precentral gyrus by an annectant gyrus. It is broken up anteriorly into two parts, upper and lower, by an antero-posterior secondary sulcus ; and it is cut into behind by the upper portion of the inferior part of the precentral sulcus.

The **inferior frontal gyrus** lies below the inferior frontal sulcus, and in front of the lower part of the precentral sulcus. The anterior horizontal and the ascending limbs of the fissure of Sylvius enter it and subdivide it into three parts, namely, pars orbitalis, pars

triangularis, and pars basilaris. The *pars orbitalis* lies below the anterior horizontal limb of the fissure of Sylvius; the *pars triangularis* is situated between the anterior horizontal and the ascending limbs of the fissure of Sylvius; and the *pars basilaris* is placed between the ascending limb of the fissure of Sylvius and the lower part of the precentral sulcus. The inferior frontal gyrus is connected posteriorly with the lower end of the ascending frontal or precentral gyrus by an annectant gyrus.

The inferior frontal gyrus of the *left side* is specially important, inasmuch as the **speech-centre** is assigned to the portion of it which forms the *pars triangularis* (**le cap of Broca**).

Inferior or Orbital Surface of the Frontal Lobe.—This surface presents two sulci, olfactory and orbital.

The **olfactory sulcus** is parallel to the mesial border, from which it is separated by the gyrus rectus. It lodges the olfactory tract and olfactory bulb. The **orbital sulcus** (**triradiate sulcus** of Turner) is of very variable form, but, as a rule, bears some resemblance to the letter H. It has therefore three limbs—inner, outer, and transverse. The *inner limb* is separated from the olfactory sulcus by the internal orbital gyrus. The *outer limb* is curved, and has external to it the orbital part of the inferior frontal gyrus. The *transverse limb* passes in a more or less curved manner between the inner and outer limbs.

The **gyri** of the orbital surface are as follows: gyrus rectus, internal orbital gyrus, anterior orbital gyrus, external orbital gyrus, and posterior orbital gyrus.

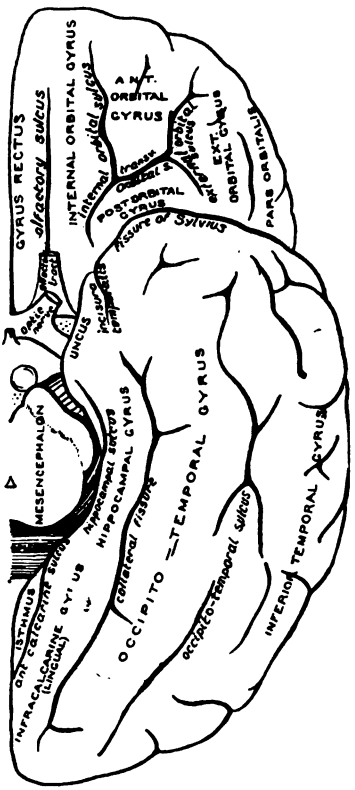


FIG. 562.—THE INFERIOR SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING THE GYRI AND SULCI.

The **gyrus rectus** lies between the olfactory sulcus and the mesial border. The **internal orbital gyrus** is placed between the olfactory sulcus and the inner limb of the orbital sulcus. The **external orbital gyrus** is external to the outer limb of the orbital sulcus. The **anterior orbital gyrus** is situated in front of the transverse limb of the orbital sulcus. The **posterior orbital gyrus** lies behind the transverse limb of the orbital sulcus.

Internal Surface of the Frontal Lobe.—The internal or mesial surface presents only one convolution, namely, the **marginal gyrus,** which is situated between the supero-mesial border of the hemisphere and the calioso-marginal sulcus. It is continuous with the superior frontal gyrus, and anteriorly is broken up by one or two sulci. Its posterior part is almost completely detached, and forms the **paracentral lobule,** which contains the upper end of the fissure of Rolando.

Parietal Lobe.—This lobe is bounded *anteriorly* by the fissure of Rolando, which separates it from the frontal lobe. *Posteriorly*

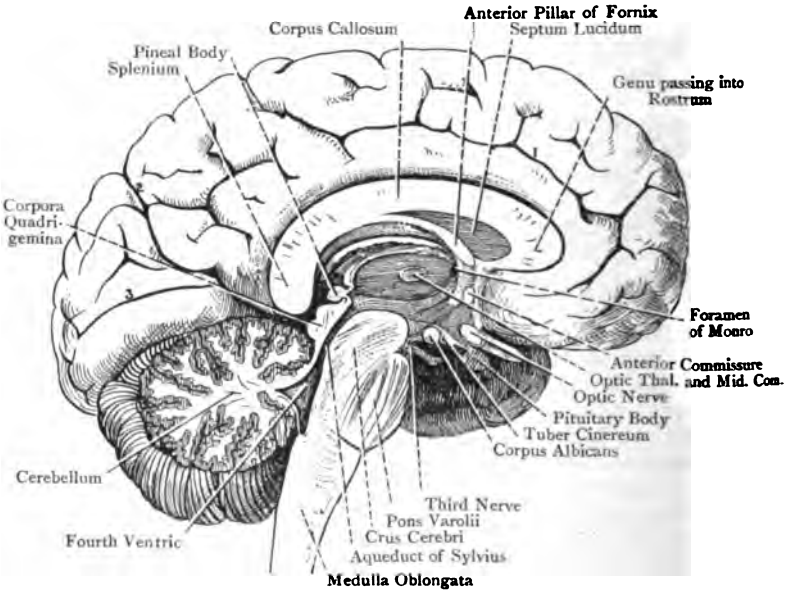


FIG. 563.—THE MESIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

it is bounded by (1) the external part of the parieto-occipital fissure, which separates it from the occipital lobe; and (2) a line drawn across the external surface of the hemisphere from the extremity of this fissure towards the pre-occipital notch. Along this line the parietal and occipital lobes are continuous. *Inferiorly* the lobe is bounded by (1) the horizontal portion of the posterior limb of the fissure of Sylvius, which separates it from the temporal lobe, and (2) a line prolonging this limb backwards to meet the posterior boundary. The *pre-occipital notch* just referred to is situated on the infero-lateral border of the hemisphere, from 1½ to 2 inches in front of the occipital pole.

The parietal lobe has two surfaces, external and internal.

External Surface.—This surface presents the following sulci: the intraparietal sulcus, composed of four parts; and the terminal portions of (*a*) the posterior limb of the fissure of Sylvius, (*b*) the first temporal or parallel sulcus, and (*c*) the second temporal sulcus.

The **intraparietal sulcus** (Turner) is composed of four parts, namely, inferior postcentral, superior postcentral, ramus horizontalis, and ramus occipitalis.

The **inferior** and **superior postcentral sulci** may be distinct, or continuous with each other. They lie behind the fissure of Rolando, with which they are parallel, and from which they are separated by the ascending parietal or postcentral gyrus.

The **ramus horizontalis** passes backwards and slightly upwards from the upper end of the inferior postcentral sulcus. It has the superior parietal gyrus above it, and the inferior parietal gyrus below it.

The **ramus occipitalis** lies behind the ramus horizontalis, with which it is usually connected. It forms the outer boundary of the gyrus which arches round the external part of the parieto-occipital fissure, namely, the *arcus parieto-occipitalis* (first annectant convolution). Posteriorly the ramus occipitalis divides into two short sulci, which diverge, one ascending, and the other descending, in the occipital lobe.

The terminal portions of (*a*) the posterior limb of the fissure of Sylvius, (*b*) the first temporal or parallel sulcus, and (*c*) the second temporal sulcus, are confined to the lower part of the external surface of the parietal lobe, where they lie in the order named, from before backwards.

The **gyri** of the external surface are as follows: ascending parietal; superior parietal; and inferior parietal, with its supramarginal, angular, and postparietal gyri.

The **ascending parietal** or **postcentral gyrus** is situated immediately behind the fissure of Rolando, which separates it from the ascending frontal or precentral gyrus in front of that fissure. Posteriorly it is limited by the superior and inferior postcentral sulci. It extends from the supero-mesial border of the hemisphere to the posterior horizontal limb of the fissure of Sylvius, and it lies parallel to the ascending frontal or precentral gyrus, with which it is connected below the fissure of Rolando.

The **superior parietal gyrus** is situated between the ramus horizontalis and the supero-mesial border of the hemisphere, where it is continuous with the quadrate lobule, or præcuneus, of the internal surface. Anteriorly it is limited by the superior postcentral sulcus, round the upper end of which it is continuous with the ascending parietal gyrus. Posteriorly it is bounded by the external part of the parieto-occipital fissure, round the extremity of which it is connected with the occipital lobe by the arcus parieto-occipitalis (first annectant convolution).

The **inferior parietal gyrus** is situated behind the inferior post-

central sulcus, and below the ramus horizontalis and ramus occipitalis. It is broken up into three gyri, namely, supramarginal, angular, and postparietal, in this order from before backwards. The *supramarginal gyrus* arches round the ascending extremity of the posterior limb of the fissure of Sylvius. It is continuous in front with the ascending parietal gyrus below the lower end of the inferior postcentral sulcus; posteriorly with the angular gyrus; and postero-inferiorly with the first temporal gyrus. The *angular gyrus* arches round the ascending extremity of the first temporal or parallel sulcus, and is continuous with the second temporal gyrus. The *postparietal gyrus* arches round the ascending extremity of the second temporal sulcus, and is continuous with the third temporal gyrus.

Internal Surface of the Parietal Lobe.—The internal or mesial

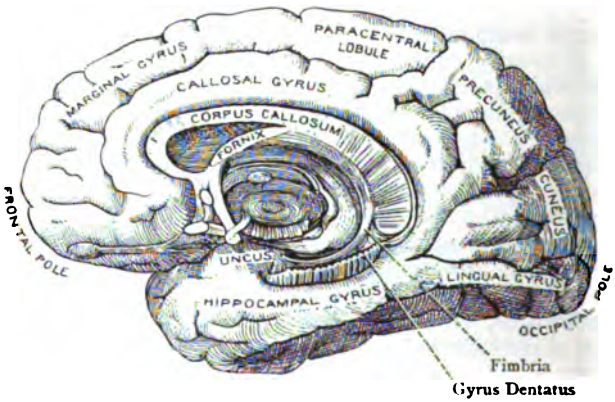


FIG. 564.—THE MESIAL SURFACE OF THE RIGHT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

surface is of quadrilateral outline, and constitutes the **quadrate lobule** or **præcuneus.** It is bounded in front by the upturned posterior extremity of the calloso-marginal sulcus, behind by the internal part of the parieto-occipital fissure, and below by the postlimbic sulcus and a portion of the limbic lobe.

Occipital Lobe.—This lobe lies behind the parietal and temporal lobes, and forms the posterior part of the cerebral hemisphere.

Externally the lobe is bounded in front by the external part of the parieto-occipital fissure, and a line connecting this fissure with the pre-occipital notch on the infero-lateral border of the hemisphere. *Internally* it is bounded in front by the internal part of the parieto-occipital fissure, which separates it from the quadrate lobule, or præcuneus, of the parietal lobe. *Inferiorly* it is continuous with the temporal and limbic lobes, but the separation may be indicated by a line connecting the pre-occipital notch with the

portion of the limbic lobe which lies below the splenium of the corpus callosum, this portion being known as the isthmus of the limbic lobe.

The occipital lobe is pyramidal, and presents an apex and three surfaces—external, internal, and inferior.

The **apex** forms the **occipital pole** of the cerebral hemisphere.

External Surface.—This surface presents two sulci, transverse occipital and lateral occipital. The **transverse occipital sulcus** is formed by the bifurcation of the posterior end of the ramus occipitalis of the intraparietal sulcus, and it crosses the upper part of the occipital lobe transversely. Its upper limb lies a little behind the external part of the parieto-occipital fissure, from which it is separated by a portion of the arcus parieto-occipitlais; and its lower limb is behind the post-parietal gyrus. The **lateral occipital sulcus** is situated on the external surface of the occipital lobe, and extends almost horizontally from behind forwards. It divides the external surface of the lobe into two parts, upper and lower, which are connected with the parietal and temporal lobes by annectant gyri.

Internal Surface.—The internal or mesial surface presents the **calcarine fissure.** This is a deep cleft which commences on the internal aspect of the occipital pole in a bifurcated manner. It takes a curved course forwards, passing at first upwards and then downwards, and it terminates by entering the limbic lobe beneath the splenium of the corpus callosum. It is joined at a point anterior to its centre by the internal part of the parieto-occipital fissure, and between the two fissures is the *cuneus*. The calcarine fissure may be regarded as being composed of two parts, anterior, representing the portion in front of the internal part of the parieto-occipital fissure, and posterior, representing the portion behind that fissure. The *anterior calcarine fissure* gives rise to the hippocampus minor, or calcar avis, on the inner wall of the posterior cornu of the lateral ventricle.

The **gyri** of the internal surface are two in number, namely, the cuneus and the gyrus lingualis.

The **cuneus** is triangular, and is wedged in between the posterior calcarine fissure and the internal part of the parieto-occipital fissure. The **gyrus lingualis** (infracalcarine gyrus) is situated between the calcarine fissure above and the posterior part of the collateral fissure below. Anteriorly it becomes narrow, and joins the hippocampal gyrus. The lower portion of this gyrus is visible on the inferior surface of the lobe.

Inferior Surface.—The inferior or tentorial surface presents the posterior part of the occipito-temporal gyrus, internal to which is the posterior part of the collateral fissure, and internal to this again there is the lower portion of the gyrus lingualis.

Temporal Lobe.—The temporal (temporo-sphenoidal) lobe is prominent, and of large size. It is situated below the posterior horizontal limb of the fissure of Sylvius, and behind the stem of that fissure. Superiorly it is bounded by (1) the horizontal portion

of the posterior limb of the fissure of Sylvius, and (2) a line prolonging this limb backwards to meet the posterior boundary of the parietal lobe. Anteriorly it is bounded by the stem of the fissure of Sylvius, which separates it from the orbital area of the frontal lobe. Posteriorly it is continuous with the occipital lobe, but the separation may be indicated by the following lines: externally by a line connecting the extremity of the external part of the parieto-occipital fissure with the pre-occipital notch, and inferiorly by a line connecting the pre-occipital notch with the portion of the limbic lobe which lies below the splenium of the corpus callosum (isthmus of the limbic lobe). Inferiorly it is separated from the hippocampal gyrus by the collateral fissure. The temporal lobe is somewhat pyramidal, the rounded apex being directed forwards. The apical part forms the **temporal pole,** and it overhangs from behind the stem of the fissure of Sylvius. The uncus of the hippocampal gyrus lies on its inner side, but on a more posterior level, and separated from it by the temporal sulcus.

The lobe presents three surfaces—superior, external, and inferior.

The **superior** or **opercular surface** is concealed within the fissure of Sylvius, and is directed towards the island of Reil.

The **external surface** presents two horizontal sulci and three convolutions, the latter being disposed in horizontal tiers.

The **sulci** are called first temporal and second temporal, respectively. The **first temporal sulcus** is parallel to the posterior limb of the fissure of Sylvius, from which circumstance it is called the parallel sulcus. It commences near the temporal pole, and posteriorly it turns upwards into the parietal lobe, where the angular gyrus arches round it. The **second temporal sulcus** is parallel to the first, below which it lies, and it is usually broken up into two or more parts by annectant gyri. Posteriorly it turns upwards into the parietal lobe, where the postparietal gyrus curves round it.

The **gyri** of the external surface, as stated, are arranged in horizontal tiers, and are three in number, first, second, and third, in this order from above downwards.

The **first temporal gyrus** is situated between the posterior limb of the fissure of Sylvius and the parallel sulcus. Posteriorly it is continuous with the supramarginal, and slightly with the angular, gyri of the parietal lobe. The **second temporal gyrus** lies between the parallel and second temporal sulci, and posteriorly is continuous with the angular and postparietal gyri of the parietal lobe. The **third temporal gyrus** lies below the second temporal sulcus, and posteriorly is continuous with the lower part of the external surface of the occipital lobe.

The **inferior** or **tentorial surface** of the temporal lobe presents the occipito-temporal sulcus and the occipito-temporal gyrus. The **occipito-temporal sulcus** extends from before backwards, lying near the infero-lateral margin of the hemisphere, and external to the collateral fissure. It is usually broken up into parts by annectant

convolutions. The **occipito-temporal gyrus** is situated between the occipito-temporal sulcus and the collateral fissure, and extends from the occipital pole to the temporal pole. External to the occipito-temporal sulcus there is the narrow inferior or tentorial surface of the third temporal gyrus.

Island of Reil, Central Lobe, or Insula.—This lobe is situated deeply within the fissure of Sylvius, and is concealed from view by the opercular gyri, to be presently described. It is triangular, the apex being directed downwards towards the vallecula Sylvii and locus perforatus anticus. The circular or limiting sulcus being here absent, the grey matter of the apex is continuous with that of the locus perforatus anticus, this point being called the *limen insulæ*. Elsewhere the island of Reil is surrounded by the circular or limiting sulcus, which has been already described. The insula presents several sulci, which diverge as they pass from the apical region to the base, and these map it out into gyri. One of these sulci is known as the **sulcus centralis insulæ.** It extends from the apex to the base in an upward and backward direction, almost in line with the fissure of Rolando, and it divides the insula into two lobules, precentral and postcentral.

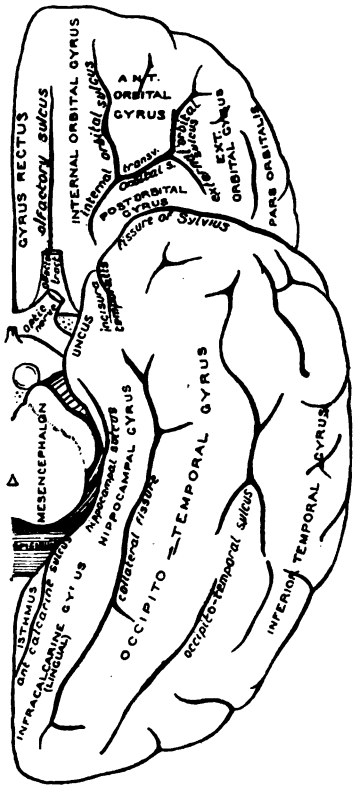


FIG. 565.—THE INFERIOR SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING THE GYRI AND SULCI.

The **precentral lobule** is composed of three short gyri, called the *gyri breves*, which converge as they descend from the base, but they do not reach the apex or **pole** of the precentral lobule. The **postcentral lobule** is formed by the *gyrus longus*, which is usually broken up into two gyri towards the base of the insula.

The direct internal or mesial relation of the insula is the claustrum, internal to which there are, in succession, the external capsule, the nucleus lenticularis, the internal capsule, and the nucleus caudatus.

The insula and the corpus striatum represent the **stem** of the cerebral hemisphere, whilst the remainder of the hemisphere is known as the **pallium** or **mantle.**

Opercula Insulæ.—The parts of the cerebral hemisphere which bound the three limbs of the fissure of Sylvius and overhang the insula are called the **opercula insulæ.** They are four in number, namely, fronto-parietal, temporal, frontal, and orbital.

The **fronto-parietal operculum** forms the upper lip, and the **temporal operculum** forms the lower lip, of the posterior limb of the fissure of Sylvius. The **frontal operculum** represents the *pars triangularis* of the inferior frontal gyrus—that is to say, the part which lies between the ascending and the anterior limbs of the fissure of Sylvius. The **orbital operculum** represents the *pars orbitalis* of the inferior frontal gyrus, and lies below the anterior limb of the fissure of Sylvius.

Limbic Lobe.—This lobe is situated on the internal or mesial surface of the cerebral hemisphere. It is composed of two convo-

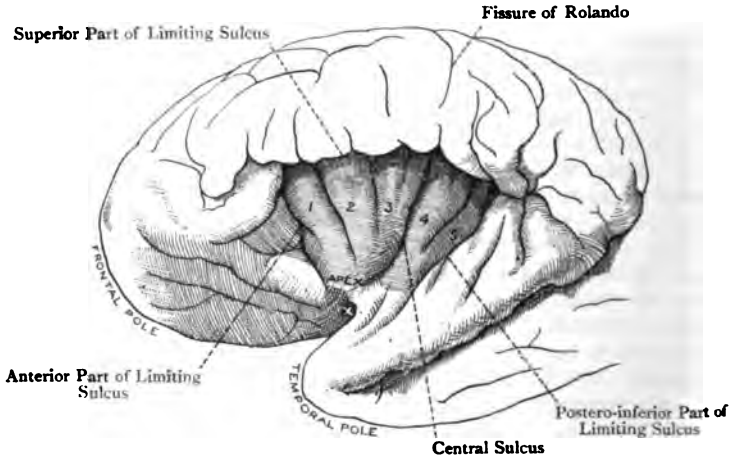


FIG. 566.—THE LEFT ISLAND OF REIL (POIRIER, FROM EBERSTALLER).

1, 2, 3, Gyri Breves; 4, 5, Gyri Longi; ×, Limen Insulæ.

lutions, namely, the callosal gyrus, or gyrus fornicatus, and the hippocampal gyrus, so disposed as to form an almost complete ring round the corpus callosum and subjacent parts. The open part of the ring, which is very small, is situated at the locus perforatus anticus, and is occupied by the roots of the olfactory tract. Around its circumference the limbic lobe is bounded superiorly by the calloso-marginal fissure, posteriorly by the postlimbic sulcus, and inferiorly by the anterior part of the collateral fissure and the *incisura temporalis*. The callosal and hippocampal gyri become continuous beneath the splenium of the corpus callosum, the connecting portion, which is narrow, being known as the *isthmus of the limbic lobe*.

The **callosal gyrus** is intimately related to the corpus callosum, round which it arches: hence the name **gyrus fornicatus.** It com-

mences at the locus perforatus anticus, below the rostrum of the corpus callosum, and it terminates below the splenium of that body. Between these two points it pursues a sweeping course, passing forwards beneath the rostrum, upwards in front of the genu, backwards above the body of the corpus callosum, and finally curving round the splenium, to be continued into the hippocampal gyrus through the *isthmus*. It is bounded superiorly by the calloso-marginal fissure, which separates it from the marginal gyrus and paracentral lobule, and, posterior to the latter, it is partially separated from the præcuneus by the postlimbic sulcus. The callosal gyrus is separated from the corpus callosum by the **callosal sulcus.**

The **hippocampal gyrus** extends from a point below the splenium of the corpus callosum to the locus perforatus anticus. Posteriorly it is continuous with the callosal gyrus through the *isthmus*, and anteriorly it is connected with the outer root of the olfactory tract, the inner root of that tract being connected with the anterior part of the callosal gyrus. It forms the lower part of the limbic lobe, and does not extend quite so far forwards as the temporal pole. In this region it is bent backwards upon itself, and this recurrent anterior portion is called the **uncus.**

The hippocampal gyrus is bounded externally by the anterior part of the collateral fissure and the *incisura temporalis*, which latter separates the uncus from the adjacent portion of the temporal lobe. Internally it is bounded by the hippocampal or dentate fissure. Posteriorly the calcarine fissure enters it, and divides it into two parts, upper and lower. The upper part is the *isthmus*, which connects it with the callosal gyrus, and the lower part is continuous with the gyrus lingualis.

Cingulum.—The cingulum is a tract of *long association fibres*, which is connected with the limbic lobe. It commences near the locus perforatus anticus and is closely related to the callosal and hippocampal gyri, lying upon the inferior surface of the former and the superior surface of the latter. The fibres of the cingulum are regarded as connecting the gyri of the limbic lobe with the cortex of the cerebral hemisphere.

Hippocampal or Dentate Fissure.—This fissure commences behind the splenium of the corpus callosum, where it is continuous with the callosal sulcus. It is directed forwards, lying between the gyrus dentatus above and the hippocampal gyrus below, and it terminates within the uncus of the hippocampal gyrus.

The hippocampal or dentate fissure, being complete, gives rise to the elevation in the descending cornu of the lateral ventricle, called the hippocampus major.

Gyrus Dentatus (*Fascia Dentata* of Tarinus).—The gyrus dentatus is situated above the hippocampal gyrus, and below the fimbria. It is separated from the hippocampal gyrus by the hippocampal fissure, and from the fimbria by a slight groove, called the *fimbrio-dentate sulcus*. The dentate gyrus is narrow, and its free margin

is indented or notched: hence the name *dentatus*. It commences behind the splenium of the corpus callosum, and is directed forwards above the hippocampal gyrus into the curve of the uncus. Here it describes a bend, after which it emerges from the curve of the uncus, and, crossing the recurved part, is lost on its outer aspect. This portion of the dentate gyrus is called the *frenulum Giacomini*.

Posteriorly it is continuous round the splenium with the rudimentary *gyrus supracallosus*, which contains the *mesial* and *lateral longitudinal striæ* of one half of the upper surface of the corpus callosum.

Fimbria.—The fimbria is the prolongation of the posterior pillar of the fornix. It is situated above the gyrus dentatus, from which it is separated by the fimbrio-dentate sulcus. Posteriorly it turns upwards round the posterior extremity of the optic thalamus, and so becomes continuous with the posterior pillar of the fornix. Anteriorly it enters the uncus.

Development of the Cerebral Hemispheres.—Each hemisphere is developed from the wall of the **cerebral vesicle**, which is a hollow protrusion from the upper and lateral part of the telencephalon, one of the divisions of the prosencephalon. The anterior wall of that portion of the telencephalon which lies between the two cerebral vesicles is called the **lamina terminalis.**

The hemispheres grow out of proportion to the other parts of the encephalon in a forward, upward, and backward direction. Their backward growth is so great that they completely cover the other parts of the encephalon by the seventh month of intra-uterine life.

The sulci and gyri of the hemispheres first appear about the fifth month of intra-uterine life.

Development of the Insula and **Fissure of Sylvius.**—The insula, or island of Reil, appears as a depression, called the **Sylvian fossa**, on the lateral aspect of the cerebral vesicle. The wall of this fossa becomes developed into the *opercula insulæ*, and, as these grow, they cover the insula, and give rise to the limbs of the fissure of Sylvius.

Olfactory Lobe.

The olfactory lobe is rudimentary in man. It is composed of two lobules, anterior and posterior (His).

Anterior Lobule.—This consists of the following parts: (1) the olfactory bulb; (2) the olfactory tract, with its two roots, mesial and lateral; (3) the trigonum olfactorium; and (4) the area of Broca.

The **olfactory bulb** is the enlarged anterior extremity of the olfactory tract. It is oval, and its upper surface is in contact with the orbital surface of the frontal lobe, whilst its lower surface rests upon one half of the cribriform plate of the ethmoid bone. The lower surface receives the olfactory nerves, which arise from the olfactory cells of the olfactory mucous membrane and pass through the foramina of the cribriform plate.

The **olfactory tract** is a white band which extends backwards from the olfactory bulb, both of them occupying the olfactory sulcus on the inner part of the orbital surface of the frontal lobe. Posteriorly it divides into two roots, inner and outer, which diverge and enclose between them the trigonum olfactorium.

The **inner** or **mesial root** passes inwards, in a curved manner,

behind the area of Broca. Some of its fibres pass into this area, and others enter the anterior extremity of the callosal gyrus, or gyrus fornicatus.

The **outer** or **lateral root** passes backwards and outwards over the outer part of the posterior lobule (locus perforatus anticus), and enters the anterior part of the hippocampal gyrus.

The **trigonum olfactorium** is the area of grey matter which lies

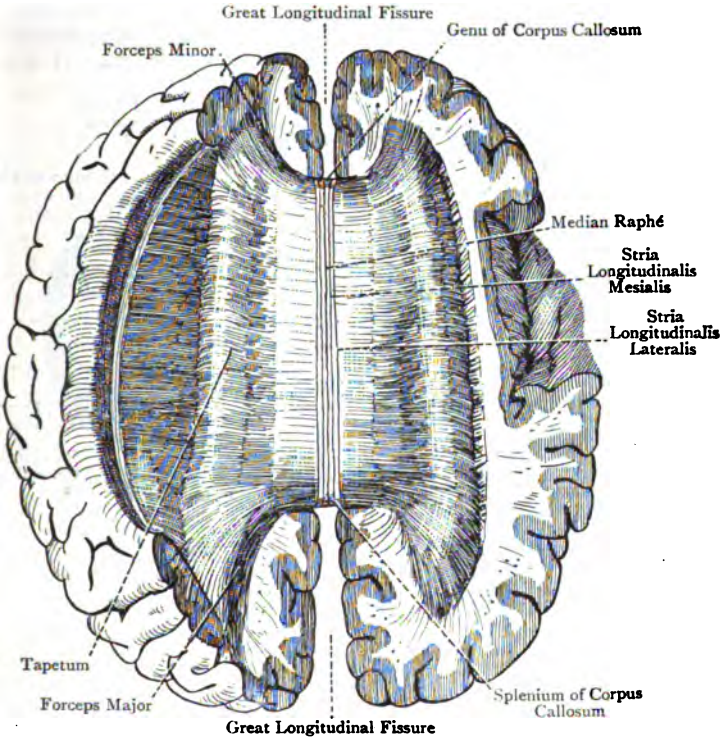


FIG. 567.—THE CORPUS CALLOSUM (SUPERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

between the diverging mesial and lateral roots of the olfactory tract. It is sometimes described as the *middle* or *grey root* of the olfactory tract.

The **area of Broca** is the portion of grey matter which is situated in front of the inner or mesial root of the olfactory tract. It is continuous with the commencement of the callosal gyrus.

Posterior Lobule.—This represents that portion of the cerebral cortex which corresponds to the locus perforatus anticus. Anteriorly it is separated from the anterior lobule by the *fissura prima* of His;

externally it is prolonged into the vallecula Sylvii; and internally it is limited by the gyrus subcallosus or peduncle of the corpus callosum.

Development.—The olfactory lobe is developed as a hollow protrusion from the antero-inferior part of the cerebral vesicle. This protrusion becomes solid, and gives rise to the olfactory tract and olfactory bulb.

Corpus Callosum.—The corpus callosum is the great transverse commissure which connects the two cerebral hemispheres. It is situated at the bottom of the great longitudinal fissure, and extends nearer to the front than the back of the hemispheres. It is arched

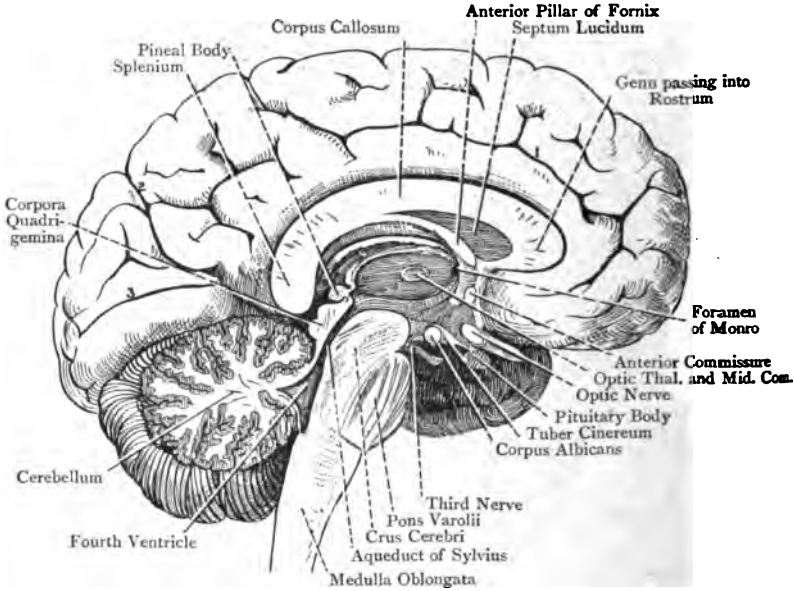


FIG. 568.—THE MESIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

from before backwards, its upper surface being convex, whilst its under surface is concave. It is thicker in front and behind than at the centre, and it attains its greatest thickness posteriorly, where more fibres cross in it than elsewhere, on account of there being more of the hemisphere behind it than in front of it.

The **superior surface** is related to the falx cerebri, but is in contact with it only posteriorly. It is covered by a thin layer of grey matter, and presents a transversely-striated appearance, indicative of the direction of its fibres. In the median line there is a slight antero-posterior furrow or **raphé,** and on either side of this there is a white longitudinal band, called the **stria longitudinalis mesialis.** The two striæ longitudinales mesiales, right and left, are sometimes

spoken of as the *nerves of Lancisi*. External to each mesial stria, and situated under cover of the gyrus fornicatus or callosal gyrus, there is another band, composed of grey matter, called the **stria longitudinalis lateralis.** Each lateral stria is sometimes spoken of as the *tænia tecta* ('covered tænia'), from the circumstance that it is covered by the callosal gyrus.

The striæ of each side may be traced posteriorly round the splenium into the corresponding gyrus dentatus. Anteriorly each mesial stria, along with the grey matter in which it lies, passes round the genu and backwards on the under surface of the rostrum, under the name of the **geniculate gyrus.** This enters the subcallosal gyrus, and finally passes to the temporal pole.

The mesial and lateral longitudinal striæ of each side, together with the thin layer of gray matter, represent a rudimentary convolution called the **supracallosal gyrus.**

The **posterior extremity** of the corpus callosum is called the **splenium.** It is very thick, which is due, as stated, to the great number of fibres which cross in it, on account of there being more of the hemisphere behind it than in front of it. The splenium is rolled upon itself, so that its lower part is directed forwards. It lies over the mesencephalon.

Anteriorly the corpus callosum is bent upon itself, and passes at first downwards and then backwards. The bent portion is called the **genu,** and the portion which passes backwards is termed the **rostrum.** The rostrum terminates in the median line by becoming connected with the lamina cinerea, and on either side it passes into the **peduncles** of the corpus callosum, otherwise known as the **subcallosal gyri.** Each subcallosal gyrus, with the contained stria longitudinalis mesialis, now called, as stated, the geniculate gyrus, passes downwards on the internal surface of the cerebral hemisphere to the locus perforatus anticus, lying in front of the lateral portion of the lamina cinerea. The geniculate gyrus then passes backwards and outwards along the posterior margin of the locus perforatus anticus, and so reaches the temporal pole.

The **inferior surface** of the corpus callosum is divisible into a mesial and two lateral portions. The *mesial portion* is connected posteriorly with the fornix, and over the remainder of its extent with the septum lucidum. Each *lateral portion* enters into the roof of the body and anterior cornu of the corresponding lateral ventricle.

Destination of the Callosal Fibres.—The transverse fibres of the corpus callosum, on entering the white medullary substance of each cerebral hemisphere, traverse it in a radiating manner as they pass to the cerebral cortex. They constitute the **radiatio corporis callosi,** and intersect in their course the fibres which pass between the internal capsule and the cerebral cortex, which form the *corona radiata*. The fibres from the central portion or body and upper part of the splenium of the corpus callosum constitute the *tapetum*. This forms the roof of the body of the lateral ventricle,

the chief part of the roof and the outer wall of the commencement of the middle or descending cornu, and the roof and outer wall of the posterior cornu. The fibres of the tapetum ultimately pass into the temporal and occipital lobes. The fibres from the region of the genu curve forwards into the front part of the frontal lobe, and form the roof of the anterior cornu of the lateral ventricle. They constitute the *forceps minor*. The fibres from the lower part of the splenium curve backwards into the occipital lobe, and give rise to an eminence on the inner wall of the posterior cornu of the lateral ventricle. They constitute the *forceps major*.

Development.—The corpus callosum may be regarded as being developed from the **lamina terminalis.**

Fornix.—This is an arched lamina of white longitudinal fibres, which lies beneath the corpus callosum, with which it is connected posteriorly, but from which it is separated anteriorly by the septum lucidum. It is composed of two lateral halves, which are united together in the median line to form the body of the fornix; but in front and behind they are separated from each other, and form the anterior and posterior pillars. The fornix is thus composed of a body, two anterior pillars, and two posterior pillars.

The **body** is triangular, being narrow in front, where it is continuous with the anterior pillars, and broad behind, where it is prolonged into the posterior pillars. The *superior surface* of the body is connected posteriorly with the corpus callosum, and anteriorly with the septum lucidum. Each *lateral border* is well defined, and projects slightly into the lateral ventricle. The *inferior surface* rests directly upon the velum interpositum, beneath which, in the median line, is the third ventricle, and on either side the upper surface of the optic thalamus.

The **anterior pillars** are two round bundles, which are continuous with the anterior part of the body, and are slightly separated from each other. They pass downwards in front of the foramina of Monro, traversing the grey matter on the sides of the third ventricle. On reaching the base of the brain each pillar becomes twisted in the form of a loop, and forms the white portion of the corresponding corpus albicans or mammillare. The fibres of the anterior pillar terminate in the grey nucleus of the corpus albicans, and from this nucleus a bundle of fibres, called the bundle of **Vicq d'Azyr,** passes upwards and backwards into the optic thalamus.

The anterior commissure lies in front of the anterior pillars.

The **posterior pillars** are prolongations of the posterior part of the body on either side. They are flattened bands, which at first adhere to the under surface of the corpus callosum. Subsequently however, each curves outwards and downwards round the posterior extremity of the optic thalamus, and enters the descending cornu of the lateral ventricle. Here the posterior pillar comes into contact with the hippocampus major, upon the surface of which some of its fibres become spread out, forming the *alveus*. The rest of the

fibres are prolonged as a narrow band of white matter, called the **fimbria,** or **tænia hippocampi,** along the inner concave border of the hippocampus major, to which it is attached, as far as the uncus. As the two posterior pillars diverge from each other they enclose between them a small triangular space on the under surface of the corpus callosum posteriorly. This space is crossed by transverse fibres, and is known as the *lyra* or *psalterium*, from its supposed resemblance to a lyre. The transverse fibres form a commissure between the two hippocampi majores, and the lyra is therefore known as the **hippocampal commissure.** Each lateral half of the fornix is to be regarded as establishing a communication between the hippocampus major, in which the majority of its fibres originate, and the optic thalamus of the same side through means of (1) the anterior pillar, (2) the corpus albicans, and (3) the bundle of Vicq d'Azyr.

Development.—The fornix may be regarded as being developed from the **lamina terminalis.**

Anterior Commissure.—This is a round bundle of white fibres which crosses the middle line immediately in front of the anterior pillars of the fornix. Anteriorly its central portion is connected with the lamina cinerea, and posteriorly the central portion appears between the anterior pillars of the fornix, where it forms part of the anterior boundary of the third ventricle, and is covered by the ventricular ependyma. On either side the commissure enters the cerebral hemisphere, and divides into two parts, olfactory and temporal. The *olfactory portion* is of small size, and enters the corresponding olfactory tract. Some of its fibres serve to connect the olfactory bulb of one side with that of the other side. The other fibres connect the olfactory bulb of one side with the temporal lobe of the opposite side. The *temporal portion* is of large size, and its fibres disappear in the white matter of the temporal lobe.

The anterior commissure serves to connect the olfactory bulbs and the temporal lobes.

Septum Lucidum.—This is a thin vertical partition which is situated between the anterior cornua of the lateral ventricles, as well as between the front parts of the bodies of these ventricles. It is triangular, being broad in front and narrow behind. Posteriorly it is attached above to the under surface of the corpus callosum, and below to the upper surface of the body of the fornix. Anteriorly it occupies the concavity behind the genu of the corpus callosum, being attached above to the corpus callosum and below to the rostrum of that body. The septum lucidum is composed of two delicate laminæ. The outer surface of each lamina looks into the corresponding lateral ventricle, and is covered by the ventricular ependyma (epithelium). The inner surface faces that of its fellow, a narrow interval, representing the fifth ventricle, intervening between the two. Each lamina consists of white

matter, which is covered by grey matter on the surface looking towards the fifth ventricle.

The two laminæ are formed from portions of the mesial walls of the two cerebral hemispheres which have become detached in the course of the development of the corpus callosum and fornix.

Fifth Ventricle.—The fifth ventricle, or **ventricle of the septum,** is the narrow cleft-like interval between the two laminæ of the septum lucidum. It is a closed space, and has therefore no communication with the other ventricles. It is destitute of any ependymal lining, and contains a very little fluid.

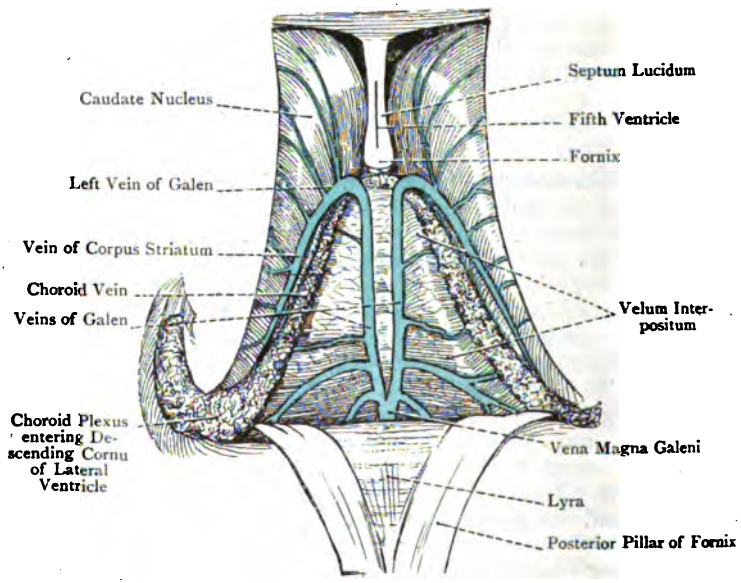


FIG. 569.—THE VELUM INTERPOSITUM AND VEINS OF GALEN.

As regards **development,** it differs from the other ventricles, having been originally a part of the great longitudinal fissure.

Velum Interpositum.—This is also known as the *tela choroidea superior*, in contradistinction to the *tela choroidea inferior*, which is the pia mater forming the roof of the lower part of the fourth ventricle. It lies immediately beneath the fornix, and rests upon the ependymal roof of the third ventricle, and also upon the adjacent portions of the optic thalami. It consists of two layers of pia mater, and is triangular, the apex being situated behind the anterior pillars of the fornix at the foramina of Monro and the base lying beneath the splenium of the corpus callosum. In the latter situation the two layers of the velum interpositum become

continuous with the pia mater, which has entered through the **transverse fissure,** situated between the splenium of the corpus callosum and the corpora quadrigemina. On either side the velum interpositum projects beyond the lateral border of the fornix, and appears as a vascular fringe in the lateral ventricle, where it is covered by the ventricular ependyma. This fringe is known as the **choroid plexus of the lateral ventricle.** Posteriorly it is prolonged into the descending cornu. Anteriorly it approaches its fellow of the opposite side, and the two unite in the median line behind the foramina of Monro. From this junction two other choroid plexuses extend backwards on the inferior surface of the velum interpositum, one on either side of the median line. They form the **choroid plexuses of the third ventricle,** and lie superficial to the ependymal roof of that cavity.

The principal veins in connection with the velum interpositum are the two choroid veins and the two veins of Galen. The **choroid vein** of each side is situated in the choroid plexus of the lateral ventricle. It passes forwards and inwards to a point behind the corresponding foramen of Monro, where it joins the **vein of the corpus striatum,** which lies between the optic thalamus and the corpus striatum. In this manner the vein of Galen of one side is formed.

The **veins of Galen** are two in number, right and left. Each vein is formed, as just stated, by the union between the choroid vein and the vein of the corpus striatum behind the corresponding foramen of Monro. The two veins of Galen pass backwards within the velum interpositum, one on either side of the median line. At first they are near each other; then they diverge; but subsequently they again come together and unite to form one vessel, called the **vena magna Galeni,** which opens into the anterior extremity of the straight sinus. Each vein of Galen receives numerous tributaries from the corresponding choroid plexus of the third ventricle, optic thalamus, corpus callosum, corpora quadrigemina, and pineal body. Near its termination it is joined by the large **basilar vein,** which is formed at the locus perforatus anticus by the union of the **anterior cerebral vein** with the **deep Sylvian vein.** The vena magna Galeni receives tributaries from the upper surface of the cerebellum and from the occipital lobes of the cerebral hemispheres.

Lateral Ventricles.

The lateral ventricles are the ventricles of the cerebral hemispheres, and are two in number, right and left. They are of irregular shape, and each occupies about two-thirds of the length of the corresponding hemisphere. They are lined with ependyma (epithelium), and contain a certain amount of cerebro-spinal fluid. Each ventricle communicates with the third ventricle by the foramen of Monro of its own side, which is situated between the

anterior pillar of the fornix and the front part of the optic thalamus. The lateral ventricle of either side consists of a body and three cornua—anterior, middle or descending, and posterior.

The **body** extends from the foramen of Monro to the level of the splenium of the corpus callosum. The **anterior cornu** is situated in front of the foramen of Monro, and curves forwards and outwards into the frontal lobe. The **middle** or **descending cornu**

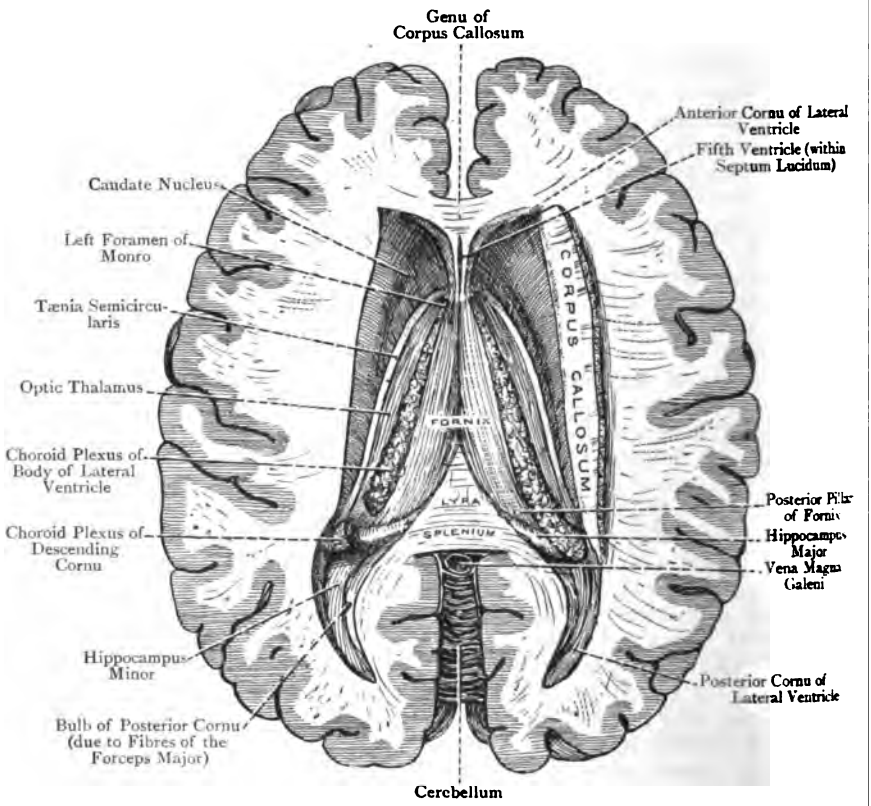


FIG. 570.—THE LATERAL VENTRICLES OF THE CEREBRUM (AFTER HIRSCHFELD AND LEVEILLÉ).

enters the temporal lobe, and describes a remarkable curve as it sweeps round the posterior extremity of the optic thalamus. Its direction is *backwards*, *outwards*, *downwards*, *forwards*, and finally *inwards* to a point about 1 inch from the temporal pole. The **posterior cornu** curves backwards and inwards into the occipital lobe.

The **body** of the lateral ventricle presents a roof, an inner wall,

and a floor. The **roof** is formed by the corpus callosum (tapetum). The **inner wall** is formed by the posterior part of the septum lucidum, and, behind this, by the attachment of the body of the fornix to the under surface of the corpus callosum. *Externally* the body is limited by the meeting of the roof and floor. The **floor** presents the following structures, in order from within outwards: (1) the sharp lateral border of the fornix; (2) the choroid plexus of the lateral ventricle; (3) a portion of the upper surface of the optic thalamus; (4) an oblique groove, extending forwards and inwards

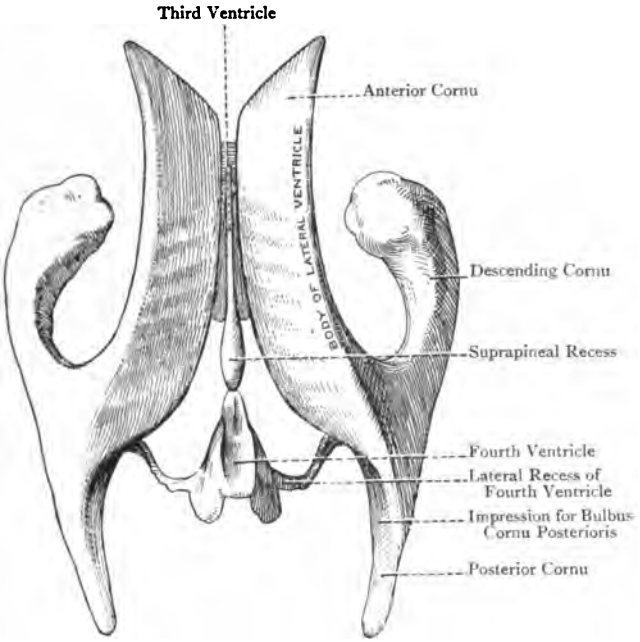


FIG. 571.—DRAWING OF A METAL CAST OF THE VENTRICLES OF THE BRAIN OF AN ADULT (SUPERIOR VIEW) (RETZIUS).

between the optic thalamus and nucleus caudatus, in which there are (*a*) a white band, called the **tænia semicircularis,** and (*b*) the vein of the corpus striatum, the latter being the more superficial of the two; and (5) the narrow part of the nucleus caudatus of the corpus striatum.

The **anterior cornu** has its **roof** formed by the corpus callosum (forceps minor). *Externally* it is limited by the meeting of the roof and floor. *Anteriorly* where it is pointed, it is bounded by part of the posterior aspect of the genu of the corpus callosum. Its **inner wall** is formed by the anterior part of the septum lucidum.

The **floor** presents a prominent swelling, which is the large round extremity of the nucleus caudatus of the corpus striatum.

The **posterior cornu** has its **roof** and **outer wall** formed by the tapetum of the corpus callosum. The **inner wall** presents two elongated, curved eminences, upper and lower. The *upper* eminence is produced by the fibres of the forceps major as they sweep backwards from the lower part of the splenium of the corpus callosum to the occipital lobe. It is called the **bulb of the posterior cornu.** The *lower* eminence is called the **calcar avis** or **hippocampus minor,**

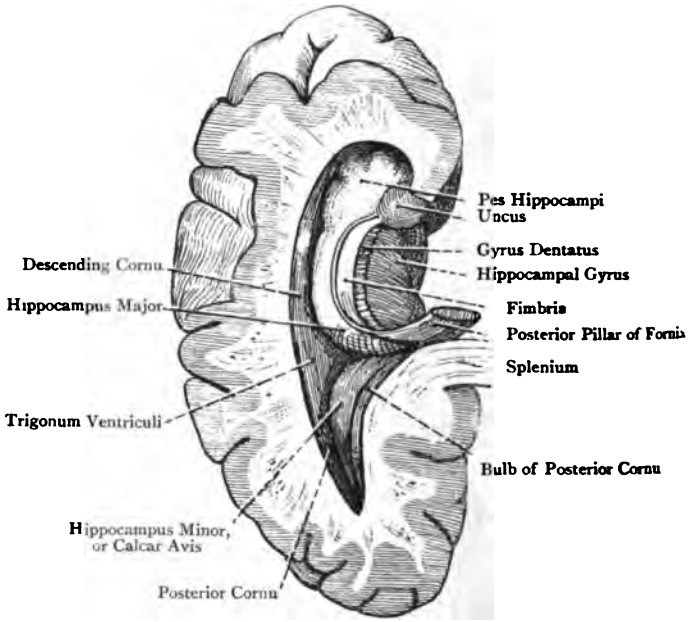


FIG. 572.—THE DESCENDING AND POSTERIOR CORNUA OF THE LEFT LATERAL VENTRICLE (AFTER HIRSCHFELD AND LEVEILLÉ).

(The Descending Cornu has been laid open throughout its entire extent).

and is produced by the anterior calcarine fissure on the mesial surface of the cerebral hemisphere.

The **middle** or **descending cornu** is situated in the temporal lobe. Its **roof** is formed chiefly by the tapetum of the corpus callosum, and, at the deep end of the cornu, presents the **amygdaloid tubercle,** which is produced by a collection of grey matter, called the **amygdaloid nucleus.** The narrow part or tail of the nucleus caudatus and the tænia semicircularis are prolonged into the roof, and extend in it as far as the amygdaloid nucleus. The **floor** of the descending cornu presents the following structures: (1) the hippocampus major, or cornu Ammonis; (2) the fimbria or tænia hippo-

campi; (3) the eminentia collateralis, or pes accessorius; and (4) the choroid plexus of the descending cornu. The **hippocampus major,** or **cornu Ammonis,** is a prominent curved elevation which traverses the entire length of the descending cornu, accurately adapting itself to its curves. It enlarges as it descends, and beneath the amygdaloid tubercle it terminates in a swelling, which is notched on the surface. This swelling is called the **pes hippocampi.**

The hippocampus major is produced by the dentate or hippocampal fissure on the mesial surface of the cerebral hemisphere.

The **fimbria,** or **tænia hippocampi,** is the continuation of the posterior pillar of the fornix. It lies along the inner concave border of the hippocampus major, to which it is attached, and it is composed of white fibres, some of which form the layer on the surface of the hippocampus major, called the *alveus.*

The **eminentia collateralis,** or **pes accessorius,** is an elevation which is situated in the angle between the descending and posterior cornua, where there is a small triangular space, called the *trigonum ventriculi.* It extends backwards into the posterior cornu, and for a variable distance into the descending cornu.

The eminentia collateralis is produced by the central portion of the collateral fissure on the tentorial surface of the cerebral hemisphere.

The **choroid plexus of the descending cornu** rests upon the surface of the hippocampus major, and is continuous with that of the body of the lateral ventricle. It is covered by the ependyma of the inner wall of the descending cornu, which it invaginates. When the choroid plexus is removed its ependymal covering comes away along with it, and the choroidal fissure then becomes apparent.

The **choroidal fissure** is situated between the fimbria and the roof of the descending cornu, and, curving round the back part of the optic thalamus, it is traceable as far forwards as the foramen of Monro of the same side. In the other direction it extends to the lower extremity of the descending cornu. It is produced by an invagination of the ventricular ependyma, which invests the choroid plexus. In the undisturbed state the fissure is occupied by the choroid plexus, covered by ependyma. By means of the choroidal fissure the ventricular cavity communicates with the mesial surface of the cerebral hemisphere.

Development.—The **lateral ventricles** represent the cavities of the primitive cerebral vesicles. The **choroidal fissure** is developed as an invagination of the mesial wall of the cerebral vesicle; and the choroid plexus is developed from a growth of mesoblast into the choroidal fissure.

Basal Ganglia of the Cerebral Hemispheres.

The basal ganglia of each cerebral hemisphere are as follows: the nucleus caudatus and nucleus lenticularis of the corpus striatum, the claustrum, and the amygdaloid nucleus.

The **corpus striatum** is a large ovoid mass, which is situated in front, and on the outer side, of the optic thalamus. It is composed of two collections of grey matter, one of which is intraventricular and the other extraventricular. The *intraventricular portion* is called

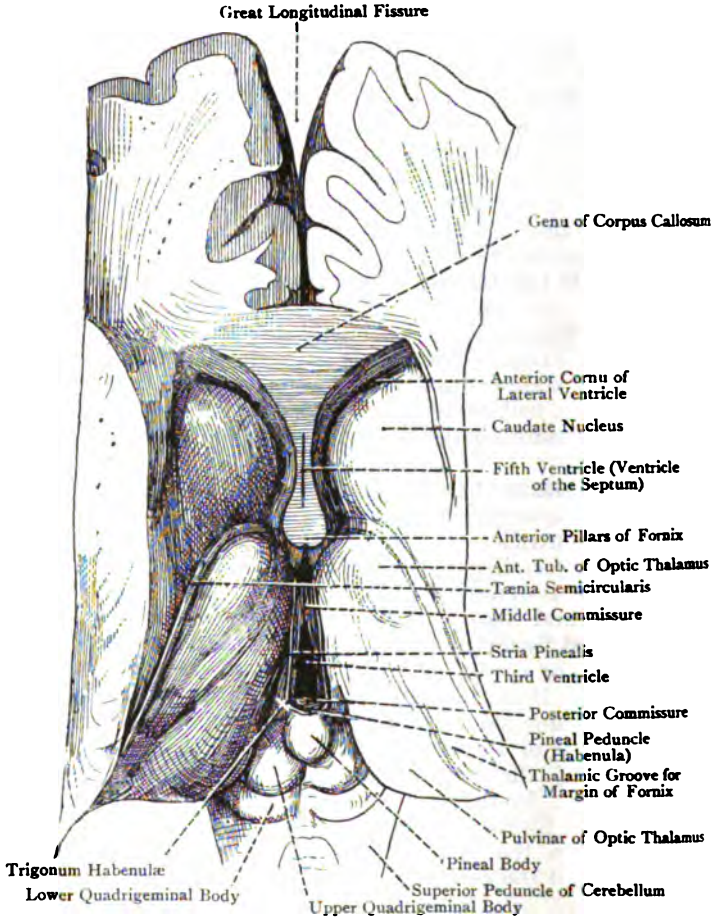


FIG. 573.—THE THIRD VENTRICLE, PORTIONS OF THE LATERAL VENTRICLES, PINEAL BODY, AND CORPORA QUADRIGEMINA (SUPERIOR VIEW) (HENLE).

(The Corpus Callosum, Fornix, and Velum Interpositum have been removed).

the **nucleus caudatus.** The *extraventricular portion* is embedded in the white matter of the cerebral hemisphere, and is termed the **nucleus lenticularis.** Between these two nuclei there is a part of the thick tract of white fibres which constitutes the **internal cap-**

sule; and on the outer side of the nucleus lenticularis there is the thin lamina of white matter, called the **external capsule.** When a coronal section is made through the corpus striatum on a level with the anterior part of the nucleus lenticularis, the white matter of the front part of the internal capsule is seen to be intersected by striæ of grey matter which pass between the nucleus caudatus and nucleus lenticularis. From the striped appearance thus produced the body has received the name of *corpus striatum.*

The **nucleus caudatus** is pyriform. The large round end is directed forwards, and projects into the anterior cornu of the lateral ventricle.

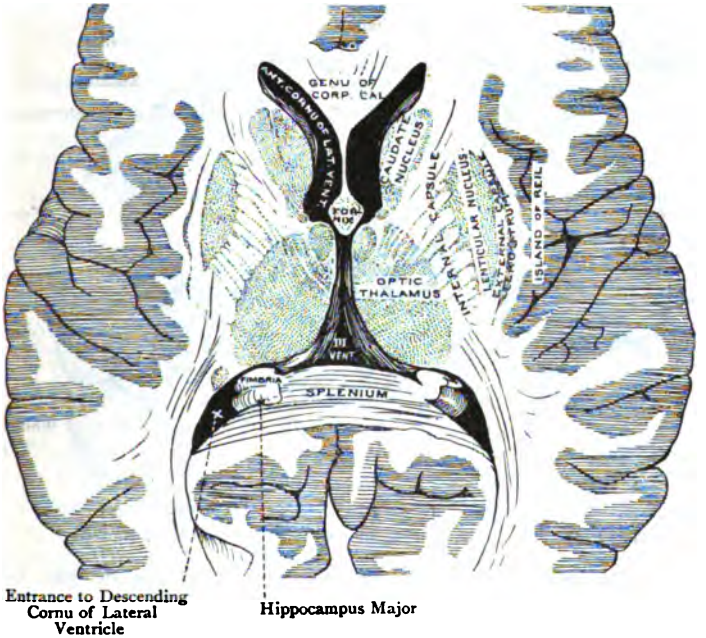


FIG. 574.—HORIZONTAL SECTION OF THE BRAIN THROUGH THE GENU AND SPLENIUM OF THE CORPUS CALLOSUM (DALTON).

The narrow portion is directed outwards and backwards in the floor of the body of the lateral ventricle, where it lies on the outer side of the optic thalamus, from which it is separated by the tænia semicircularis. Its tapering tail is continued into the roof of the descending cornu of the lateral ventricle, and is prolonged in the roof as far as the amygdaloid nucleus, in which it terminates. The nucleus caudatus is composed of grey matter, and its cells are of the multipolar variety.

The **nucleus lenticularis** is embedded in the white matter of the cerebral hemisphere, and lies on the outer side of the nucleus

caudatus and optic thalamus, from both of which it is separated by the internal capsule. It is of more limited extent than the nucleus caudatus, and receives its name from the fact that, in horizontal section, it presents the appearance of a biconvex lens, the broadest part being on a level with the front of the optic thalamus. Anteriorly it is closely related to the front part of the nucleus caudatus, being continuous with it inferiorly, and connected with it superiorly by striæ of grey matter which intersect the white matter of the front part of the internal capsule. The anterior part of the nucleus lenticularis, as seen in coronal section,

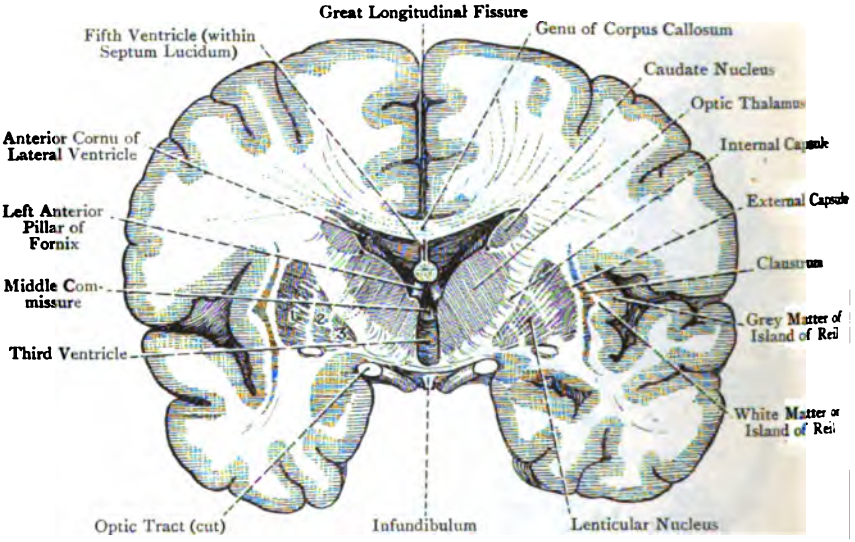


FIG. 575.—CORONAL SECTION OF THE FRONTAL PORTIONS OF THE CEREBRAL HEMISPHERES, PASSING THROUGH THE ANTERIOR CORNUA OF THE LATERAL VENTRICLES (POSTERIOR VIEW).

1, Putamen of Lenticular Nucleus; 2, 3, Globus Pallidus of Lenticular Nucleus.

is somewhat semilunar. When such a section is made through the centre, the nucleus presents a triangular outline, the base being directed towards the island of Reil, and having the external capsule in loose connection with it, whilst the internal surface is in contact with the internal capsule. In such a section the nucleus is seen to be traversed vertically by two white bands, called the *medullary laminæ*, which divide it into three zones. The outer zone, which has a dark reddish colour, is the largest, and is called the *putamen*. The inner two zones, which are somewhat yellowish, are together known as the *globus pallidus*. The putamen and globus pallidus, which consist of grey matter, are traversed by white fibres.

The grey matter of the nucleus caudatus and nucleus lenticularis comes to the surface at the base of the brain in the region of the locus perforatus anticus, where it is continuous with the grey matter of the cerebral cortex.

The **internal capsule** is the thick tract of white matter which lies between the nucleus lenticularis externally, and the nucleus caudatus, tænia semicircularis, and optic thalamus internally. As seen in horizontal section it describes a bend opposite the front part of the optic thalamus. This bend is called the **genu,** and its convexity is directed inwards. The part of the internal capsule in front of the genu is called the **anterior limb.** It forms about one-third of the entire capsule, and its direction is forwards and outwards. The part behind the genu is called the **posterior limb.** It forms about two-thirds of the entire capsule, and its direction is backwards and outwards.

The **anterior limb** of the internal capsule is situated between the front part of the nucleus lenticularis and the nucleus caudatus. Anteriorly it is intersected by the striæ of grey matter which pass between the two nuclei.

The fibres of which the anterior limb is composed are partly centripetal and partly centrifugal, the former being the most numerous. The **centripetal fibres** arise in the optic thalamus, and are arranged in two sets, according to their destination. The *thalamo-frontal fibres*, having traversed the anterior limb, pass to the cortex of the frontal lobe. The *thalamo-striate fibres*, after passing through the anterior limb, enter the nucleus caudatus and nucleus lenticularis. The chief **centrifugal fibres** form the *fronto-pontine* tract (cortico-protuberantial fibres). They arise in the cortex of the anterior part of the frontal lobe, and, having traversed the anterior limb of the internal capsule and the inner part of the crusta of the crus cerebri, they enter the pons Varolii, where they terminate in the nucleus pontis. Other centrifugal fibres constitute strio-thalamic, cortico-thalamic or fronto-thalamic, and lenticulo-caudate tracts.

The **posterior limb** of the internal capsule is situated between the back part of the nucleus lenticularis and the optic thalamus, and is prolonged backwards for a little beyond the posterior limit of the nucleus lenticularis. It is therefore conveniently divided into two parts, lenticular, representing the anterior two-thirds, and postlenticular, representing the posterior third.

The *lenticular part* of the posterior limb, like the anterior limb, is composed of centripetal and centrifugal fibres. The **centripetal fibres** arise in the optic thalamus, and their destination is the cerebral cortex. The **centrifugal fibres** represent the *pyramidal* or *motor fibres*, and they occupy the anterior portion of the lenticular part of the posterior limb of the internal capsule. These fibres descend from the Rolandic region of the cerebral cortex. Some of them pass to the nucleus of the facial nerve; others pass to the nucleus of the hypoglossal nerve; but the majority of them are destined for the motor cells in the anterior grey cornu of the spinal cord. The

fibres which pass to the facial nucleus lie close to the genu, and those which pass to the hypoglossal nucleus lie close behind the facial fibres. The fibres of the pyramidal tract occupy the central portion of the crusta of the crus cerebri in their downward course.

The *postlenticular part* of the posterior limb contains the following sets of fibres: (1) the fibres of the optic radiation, on their way from and to the optic thalamus, external geniculate body, and superior quadrigeminal body; (2) the fibres of the auditory radiation, passing between the auditory region of the temporal lobe and the internal geniculate body; and (3) the fibres of the temporo-pontine tract (cortico-protuberantial fibres), which pass from the cortex of the temporal lobe through the outer part of the crusta of the crus cerebri to the pons Varolii, where they terminate in the nucleus pontis. The internal capsule is continuous inferiorly with the crusta of the crus cerebri. Superiorly its fibres diverge in a radiating manner on their way to the cerebral cortex, forming the **corona radiata,** the fibres of which are intersected by those of the radiatio corporis callosi.

The **external capsule** is a thin lamina of white matter which is situated on the outer side of the nucleus lenticularis, where it lies between that nucleus and the claustrum. In front of and behind the nucleus lenticularis it is continuous with the internal capsule. The external capsule is, as stated, only loosely connected with the putamen of the nucleus lenticularis. The fibres of which it is composed are probably derived from the anterior white commissure and the optic thalamus.

Connections of the Corpus Striatum.—(1) The nucleus caudatus and nucleus lenticularis are partly continuous with each other, and partly connected by striæ of grey matter. (2) The corpus striatum is connected with the optic thalamus by strio-thalamic and thalamo-striate fibres. (3) The nucleus caudatus is said to be connected with the substantia nigra by a tract of fibres known as the *stratum intermedium.* (4) The nucleus lenticularis is connected with the optic thalamus by the ansa lenticularis. (5) The corpus striatum is connected with the cerebral cortex by cortico-striate fibres.

Development.—The corpus striatum is developed as a thickening of the floor of the cerebral vesicle.

The **claustrum** is a thin lamina of grey matter which is situated on the outer surface of the external capsule. It lies embedded in the white matter which occupies the region between the lenticular nucleus and the island of Reil. Superiorly it is narrow and tapering, but inferiorly it expands and reaches the surface at the base of the brain, in the region of the locus perforatus anticus. Its outer surface presents elevations and intervening depressions, which correspond to the sulci and gyri of the island of Reil.

The claustrum is regarded as an isolated portion of the grey matter of the island of Reil.

The **amygdaloid nucleus** is an oval collection of grey matter which is situated in the anterior part of the temporal lobe, where it lies in the roof of the deep extremity of the descending cornu of the lateral ventricle. The putamen of the nucleus lenticularis lies

above it; anteriorly it is continuous with the cerebral cortex; inferiorly it receives the narrow part or tail of the nucleus caudatus; and the tænia semicircularis arises from it.

The **tænia semicircularis** is a narrow white band of fibres which, as just stated, arises from the amygdaloid nucleus. The band passes backwards in the roof of the descending cornu of the lateral ventricle, and then it sweeps upwards and forwards into the body of the lateral ventricle, lying between the nucleus caudatus and the optic thalamus. At the foramen of Monro the fibres of the tænia semicircularis pass partly in front of and partly behind the anterior commissure, and they are regarded as terminating in the region of the locus perforatus anticus. Some of the fibres may enter the corresponding anterior pillar of the fornix. The vein of the corpus striatum lies superficial to the tænia semicircularis.

Relation of Structures in the Region of the Corpus Striatum.—When a coronal section has been made the relation of structures, from within outwards, is as follows:

1. Nucleus caudatus.
2. Internal capsule.
3. Nucleus lenticularis.
4. External capsule.
5. Claustrum.
6. Island of Reil.

THALAMENCEPHALON OR DIENCEPHALON.

Third Ventricle.

The third ventricle is the cleft-like interval which is situated, in the median line, between the two optic thalami. It extends from the pineal body posteriorly to the anterior pillars of the fornix in front, is very narrow from side to side, and is deeper in front than behind. The cavity presents a roof, a floor, two lateral walls, an anterior boundary, and a posterior boundary.

The **roof** is formed by a delicate layer of epithelium which extends across between the upper margins of the lateral walls, and is continuous with the ependymal lining of the ventricle. Superficial to this epithelial roof, and intimately connected with it, is the velum interpositum, from the under surface of which the two choroid plexuses of the ventricle project downwards, one on either side of the middle line, each invaginating the epithelium of the roof. The epithelium of the roof is so intimately connected with the velum interpositum that, when the latter is removed, the epithelium comes away with it, and the cavity of the ventricle is exposed. Superficial to the velum interpositum is the body of the fornix, and, above this again, is the body of the corpus callosum.

Summary of the Roof.—To expose the ventricle from above the following structures must be removed, in the order named: (1) the body of the corpus callosum; (2) the body of the fornix; and (3) the velum interpositum, along with the epithelium of the roof.

The **floor,** which is sloped downwards and forwards, is formed by the structures which lie within the interpeduncular space at

the base of the brain, these being as follows, from behind forwards: the locus perforatus posticus, the corpora albicantia or mammillaria, and the tuber cinereum, with the upper end of the infundibulum. The tegmenta of the crura cerebri enter, to a certain extent, into the floor posteriorly, and the optic commissure lies across it anteriorly. Above the optic commissure the floor presents a depression, called the *optic recess*, and behind this there is another depression or diverticulum, called the *infundibular recess*. The latter forms the upper part of the infundibulum which leads to the posterior lobe of the pituitary body.

The **lateral wall** is slightly convex, and is formed, for the most part, by the inner surface of the optic thalamus, which has a thick

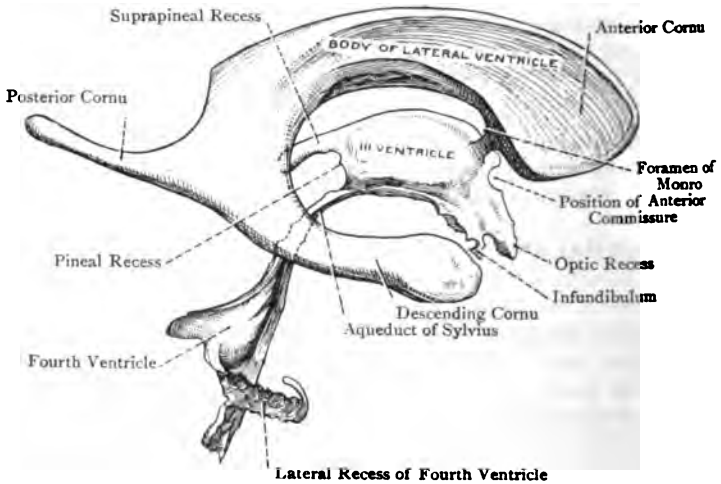


FIG. 576.—DRAWING OF A METAL CAST OF THE VENTRICLES OF THE BRAIN OF AN ADULT (RIGHT LATERAL VIEW) (RETZIUS).

covering of grey matter. Towards its centre it presents a furrow, which leads from the foramen of Monro in a backward direction towards the upper opening of the aqueduct of Sylvius. This groove is called the *sulcus of Monro*. At the upper part of the lateral wall there is a delicate band of white fibres, called the *stria pinealis* or *medullaris*, which represents the dorsal portion of the stalk of the pineal body, and passes to the anterior pillar of the fornix. Connecting the two lateral walls (optic thalami), in front of the centre of the ventricle, there is a fragile band of grey matter, called the **middle** or **soft commissure.** At the anterior part of the lateral wall the corresponding anterior pillar of the fornix passes downwards and backwards.

The **anterior boundary** is formed inferiorly by the lamina cinerea, which extends upwards from the optic commissure to the rostrum

of the corpus callosum, and superiorly by the anterior pillars of the fornix and the central portion of the anterior commissure.

The **posterior boundary** is formed by the pineal body and the posterior commissure, and under cover of the latter is the upper opening of the aqueduct of Sylvius. The posterior boundary presents two recesses, pineal and suprapineal. The *pineal recess* passes backwards above the posterior commissure into the stalk of the pineal body, separating the stalk into two portions, dorsal and ventral. The *suprapineal recess* is connected with the back part of the epithelial roof of the ventricle, and passes backwards over the pineal body. The third ventricle has thus four diverticula, namely, the optic recess, the infundibular recess, (both of which recesses are associated with the floor), the pineal recess, and the suprapineal recess. The cavity communicates with the fourth ventricle by means of the aqueduct of Sylvius, and with the two lateral ventricles by means of the foramina of Monro.

Foramina of Monro.—These are two in number, right and left, and they lead from the lateral ventricles into the third ventricle. Each foramen is situated between the anterior pillar of the fornix in front and the anterior tubercle of the optic thalamus behind. From this point the foramen of each side leads inwards and slightly downwards, and opens into the third ventricle at the anterior and upper part of the corresponding lateral wall. By means of the foramina of Monro the lateral ventricles communicate with the third ventricle, and, through that ventricle, with each other. The choroid plexuses of the lateral ventricles also become continuous with each other and with those of the third ventricle through these foramina. From each foramen a furrow, called the *sulcus of Monro*, leads, as stated, in a backward direction, over the inner surface of the optic thalamus towards the upper opening of the aqueduct of Sylvius.

Development.—The posterior and greater part of the third ventricle represents the cavity of the thalamencephalon or diencephalon; and the anterior part, in the region of the foramina of Munro, represents the mesial portion of the cavity of the telencephalon.

The foramen of Monro, of each side, represents the original wide communication between the cavity of the cerebral vesicle and the cavity of the mesial portion of the telencephalon.

Optic Thalami.—The optic thalami are two large ovoid masses of grey matter which lie obliquely, with their long axes directed backwards and outwards, for the most part on the sides of the third ventricle. Their anterior extremities are near each other, but their posterior extremities stand apart, the corpora quadrigemina being situated between them. Over their anterior two-thirds they are separated from each other by the third ventricle.

The optic thalamus presents four surfaces—superior, inferior, external, and internal; and two extremities—anterior and posterior.

The **superior surface** is limited externally by an oblique groove,

which separates it from the nucleus caudatus, and contains the tænia semicircularis and, anteriorly, the vein of the corpus striatum. Internally it is bounded, from before backwards, by (1) the stria pinealis, (2) the trigonum habenulæ, and (3) the

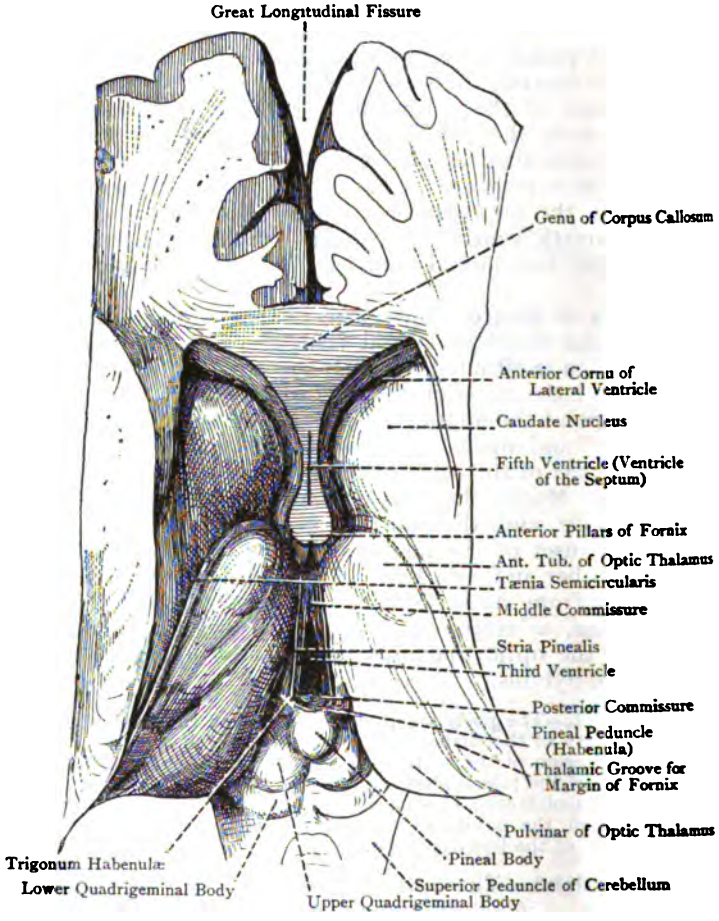


FIG. 577.—THE THIRD VENTRICLE, PORTIONS OF THE LATERAL VENTRICLES, PINEAL BODY, AND CORPORA QUADRIGEMINA (SUPERIOR VIEW) (HENLE).

(The Corpus Callosum, Fornix, and Velum Interpositum have been removed).

corpora quadrigemina. It is divided into two areæ, outer and inner, by a groove which is directed backwards and outwards from the inner border, near the anterior extremity, to the outer end of the posterior extremity. This groove corresponds to the

lateral margin of the body of the fornix. The *outer area* enters into the body of the lateral ventricle, and is covered by the ependyma of that ventricle. The *inner area* is excluded from the lateral ventricle, and is covered by portions of the velum interpositum and body of the fornix. The superior surface is covered by a thin layer of white fibres, called the *stratum zonale*, these fibres being derived from the optic tract and optic radiation.

The **inferior surface** lies posteriorly upon the upward prolongation of the tegmental fibres of the crus cerebri, which constitutes the subthalamic tegmental region, but anteriorly it rests upon the corpus albicans and a portion of the tuber cinereum.

The **external surface** is directly related to the posterior limb of the internal capsule, which separates it from the nucleus lenticularis. Many fibres emerge from this surface and enter the internal capsule on their way to the cerebral cortex, whilst others from the cerebral cortex enter the optic thalamus through this surface. These fibres constitute the thalamic radiation. On the outer surface the fibres form a well-marked reticular layer of white matter, which is called the *external medullary lamina*.

The **internal surface** faces its fellow of the opposite side, with which it is connected by means of the middle or grey commissure. It forms the lateral wall of the third ventricle, and superiorly is limited by the stria pinealis or medullaris. As stated in connection with the third ventricle, it presents the sulcus of Monro. It is covered by a thick layer of grey matter, which is continuous with that around the aqueduct of Sylvius.

The **anterior extremity** is marked by a prominence, called the *anterior tubercle*, which enters into the body of the lateral ventricle, and forms the posterior boundary of the corresponding foramen of Monro.

The **posterior extremity** presents, at its inner end, a well-marked prominence, called the *posterior tubercle* or *pulvinar*. It lies over the brachia of the corpora quadrigemina, which it almost conceals. Below and external to the pulvinar there is an oval swelling, called the *corpus geniculatum externum*. Below this body is the upper brachium of the corpora quadrigemina, and inferior to this is the *corpus geniculatum internum*.

Structure of the Optic Thalamus.—The optic thalamus is composed chiefly of grey matter. As stated, its superior surface is covered by a layer of white matter, called the *stratum zonale*, and its outer surface by a reticular layer of white matter, known as the *external medullary lamina*, the inner surface having a thick coating of grey matter, continuous with that around the aqueduct of Sylvius. The grey matter of the interior is traversed by a vertical stratum of white matter, called the *internal medullary lamina*, which breaks up into two parts and subdivides the grey matter into three nuclei—anterior, inner, and outer. The *anterior nucleus* is the smallest, and gives rise to the anterior tubercle. The fibres forming the **bundle of Vicq d'Azyr**, which arise in the corpus albi-

cans, terminate in the cells of this nucleus. The *outer* or *lateral nucleus*, which is the largest, is situated between the internal and external medullary laminæ, and extends backwards into the pulvinar. The *inner* or *mesial nucleus* lies between the internal medullary lamina and the thick layer of grey matter which coats the inner or ventricular surface of the optic thalamus. It does not extend farther back than the trigonum habenulæ, and is consequently excluded from the pulvinar.

Connections of the Optic Thalamus.—(1) Viewing the optic thalamus as an aggregation of 'cell-stations' in the course of the centripetal fibres of the tegmentum of the crus cerebri, the tegmental fibres probably all terminate in the thalamic cells. (2) Through means of the stratum zonale the optic thalamus is connected with the optic tract and optic radiation. (3) The cells of the anterior nucleus receive the fibres of the bundle of Vicq d'Azyr, which are continuous, through the corpus albicans, with the fibres of the anterior pillar of the fornix. (4) **Thalamic Radiation.**—This is composed of **thalamo-cortical fibres** which arise within the optic thalamus as the axons of the thalamic cells. They issue from its external and inferior surfaces, and pass to all parts of the cerebral cortex. They are conveniently arranged in four groups or **stalks**—frontal, parietal, occipital, and inferior or ventral. (*a*) The fibres of the **frontal stalk,** having emerged from the front part of the external surface, traverse the anterior limb of the internal capsule, and most of them pass to the cortex of the frontal lobe. Some of these fibres are thalamo-caudate and thalamo-lenticular, as regards their destination. (*b*) The **parietal stalk**, having issued from the external surface of the optic thalamus, passes for the most part through the internal capsule, but also, to a certain extent, through the external capsule, to the cortex of the parietal lobe, and the Rolandic region of the frontal lobe. (*c*) The **occipital stalk** issues from the outer part of the pulvinar, and, having traversed the postlenticular portion of the posterior limb of the internal capsule, it passes backwards and outwards, external to the posterior cornu of the lateral ventricle, and so reaches the cortex of the occipital lobe. (*d*) The **inferior or ventral stalk** emerges from the front part of the inferior surface of the optic thalamus, and its fibres arise as the axons of the cells of the outer and inner nuclei. The most superficial of these fibres constitute a band, called the *ansa lenticularis*, which enters the nucleus lenticularis, where it terminates. The remaining fibres pass outwards beneath the nucleus lenticularis to the cortex of the temporal lobe and island of Reil.

Besides the thalamo-cortical fibres there are **cortico-thalamic fibres,** which pass from the various parts of the cerebral cortex into the optic thalamus, where they terminate in arborizations around the thalamic cells.

Development.—The optic thalamus is developed as a thickening of the lateral wall of the thalamencephalon or diencephalon.

Corpus Geniculatum Externum.—This body is situated on the posterior extremity of the optic thalamus, where it lies below and external to the pulvinar. It is connected internally with the upper quadrigeminal body by the superior brachium. In structure it is composed of layers of grey and white matter, disposed alternately, the white fibres being derived from the optic tract and optic radiation.

Development.—The corpus geniculatum externum appears as an elevation on the lateral wall of the thalamencephalon or diencephalon.

Subthalamic Tegmental Region.—This region represents the upward prolongation of the tegmental fibres of the crus cerebri

beneath the posterior portion of the optic thalamus. The parts to be noted are as follows : upward prolongations of the red nucleus and substantia nigra of the tegmentum of the crus cerebri ; the mesial fillet ; the fibres of the superior peduncle of the cerebellum ; and the corpus subthalamicum, or nucleus of Luys. The *red nucleus* and the *substantia nigra* gradually disappear, and are no longer visible at the level of the corpus albicans. The mesial fillet lies on the superficial and outer aspects of the red nucleus. The fibres of the superior peduncle of the cerebellum partly terminate in connection with the cells of the red nucleus, but many of them surround it in the form of a capsule. Beyond the red nucleus the mesial fillet, fibres of the superior cerebellar peduncle, and fibres which issue from the red nucleus enter the inferior surface of the optic thalamus, and terminate in connection with the thalamic cells. Some of these fibres may pass through the optic thalamus into the internal capsule, and thence to the cortex of the Rolandic region of the cerebral hemisphere. The *corpus subthalamicum* or *nucleus of Luys* is a small lenticular mass of grey matter, surrounded by white fibres, which lies on the outer side of the substantia nigra.

Pineal Body (*Epiphysis Cerebri*).—This is a small body, having a dark red colour and conical shape (hence the name *conarium*), which is situated at the back part of the third ventricle. It lies above and behind the posterior commissure, on the superior surface of the mesencephalon, where it occupies the depression between the two upper quadrigeminal bodies. Its base is directed upwards and forwards, and is attached by a peduncle or stalk (*habenula*) of white matter, into which the pineal recess of the third ventricle extends, the suprapineal recess being above the pineal body. By means of the pineal recess the **stalk** is divided into two parts, dorsal and ventral. The *dorsal part* passes outwards and forwards, on either side, along each optic thalamus, at the junction of its inner and upper surfaces, under the name of the **stria pinealis** or **medullaris.** Anteriorly it divides into two parts, upper and lower. The upper division passes upwards, and, joining the anterior pillar of the fornix, it passes to the cells in the hippocampus major. The lower division passes downwards to a group of cells which lies close to the optic commissure. The stria pinealis or medullaris is regarded as belonging to the olfactory apparatus. The *ventral part* of the pineal stalk is bent round the posterior commissure, with which it is connected.

Structure of the Pineal Body.—The pineal body is free from nervous constituents. It consists of a number of follicles, lined with epithelial cells, and containing a variable amount of calcareous matter, called *acervulus cerebri* or *brain-sand*, which is composed of calcium phosphate, calcium carbonate, magnesium phosphate, and ammonium phosphate.

Development.—The pineal body is developed as a diverticulum of the posterior part of the dorsal aspect of the thalamencephalon or diencephalon. This diverticulum for the most part becomes solid, but a portion of it persists as the pineal recess of the third ventricle.

The pineal body is regarded as representing the pineal eye of lizards.

Trigonum Habenulæ.—This is a small triangular space, which is situated in front of the upper quadrigeminal body, and between the stalk or habenula of the pineal bodyand the posterior part of the optic thalamus, in the region of the pulvinar. It contains an important group of multipolar nerve-cells, which constitute the **ganglion habenulæ.** The axons of these cells give rise to a bundle of fibres, called the *fasciculus retroflexus.* This bundle appears on the inferior aspect of the ganglion, and passes downwards and forwards in the tegmentum of the crus cerebri, where it lies on the inner side of the red nucleus. Its fibres terminate in connection with the cells of the **ganglion interpeduncularе,** which is situated in the lower part of the locus perforatus posticus.

The ganglion habenulæ receives some fibres from the stria pinealis of the same side. The remaining fibres of that stria pass across the median line to the ganglion habenulæ of the opposite side. As the fibres of opposite sides cross they form the dorsal part of the peduncle or habenula of the pineal body, and this decussation of fibres is known as the *habenular commissure.*

Posterior Commissure.—This is a band of white fibres which is situated at the back part of the third ventricle, into the posterior boundary of which it enters. It lies over the upper opening of the aqueduct of Sylvius, and on the inferior aspect of the stalk of the pineal body. The ventral part of the pineal stalk is bent round, and closely connected with, it. The fibres of the posterior commissure are regarded as arising from a nucleus in the grey matter of the ventral aspect of the Sylvian aqueduct, close above the nucleus of the third or oculo-motor nerve. As they cross the middle line they decussate with the fibres of the opposite side, and they may terminate in connection with the cells of the ganglion habenulæ. Its other connections are not definitely known.

Interpeduncular Structures.—These structures are as follows:

1. Locus perforatus posticus.
2. Corpora albicantia.
3. Tuber cinereum.
4. Infundibulum.
5. Pituitary body.

The **locus perforatus posticus** (pons Tarini) is the depressed portion of the interpeduncular space which lies between the crura cerebri as they emerge from the pons Varolii. In other words, it lies directly in front of the pons Varolii. It is covered by a layer of grey matter, which is perforated by a number of apertures for the passage of the postero-mesial branches of the two posterior cerebral arteries.

The **corpora albicantia,** or **mammillaria,** are two small, white, pea-like bodies, which lie side by side directly in front of the locus perforatus posticus. Each is composed of white matter externally, and of a grey nucleus internally. The white matter is derived from the corresponding anterior pillar of the fornix, the fibres of which

terminate in connection with the cells of the grey nucleus. This grey nucleus contains many cells, the axons of which give rise to two fasciculi, namely, the bundle of Vicq d'Azyr, and the peduncle of the corpus albicans. The **bundle of Vicq d'Azyr,** which is apparently a continuation of the anterior pillar of the fornix, enters the optic thalamus, and its fibres terminate in connection with the cells of the anterior nucleus. The **peduncle of the corpus albicans** passes downwards and backwards in the grey matter of the floor of the third ventricle to the tegmental region of the mesencephalon, but the mode of termination of its fibres is not known.

Development.—The corpora albicantia are developed from the ventral aspect of the thalamencephalon or diencephalon. Up to the fourth month of intra-uterine life they are represented by a single corpus albicans, but after that period this divides into two corpora.

The **tuber cinereum** is an elevated area of grey matter which lies in front of the corpora albicantia and behind the optic commissure, the anterior portion of each optic tract being on either side. It is continuous anteriorly with the lamina cinerea, and on either side with the grey matter of the locus perforatus anticus.

Lamina Cinerea.—This is a thin layer of grey matter which extends from the upper surface of the optic commissure to the rostrum of the corpus callosum. Posteriorly it is continuous with the grey matter of the tuber cinereum, and on either side with that of the locus perforatus anticus.

For the pituitary body and infundibulum, see pp. 1004 and 1005.

Optic Nerve, Optic Commissure, Optic Tract, and Optic Radiation.

The **optic nerves,** or nerves of sight, in the cranial cavity are connected together at the optic commissure, where some of the fibres decussate. From the back part of the commissure each nerve, under the name of the optic tract, passes backwards round the crus cerebri to its cerebral connections.

The **optic commissure** or **chiasma** is somewhat quadrilateral, and rests upon the olivary eminence and optic groove of the sphenoid bone. It lies in front of the tuber cinereum and infundibulum, and its superior surface is connected with the lamina cinerea, and is intimately related to the anterior part of the floor of the third ventricle. Each extremity is connected anteriorly with the optic nerve, and posteriorly with the optic tract. On either side of the commissure is the locus perforatus anticus. The most of the fibres of the commissure proceed from each retina in the corresponding optic nerve, being afferent or centripetal; but at the back part of the commissure there are the fibres of the inner roots of the optic tracts, which have no connection with either retina. The decussation of fibres in the commissure is only partial. The fibres which arise in the nasal or inner half of the retina cross and enter the optic tract of the opposite side. The fibres which

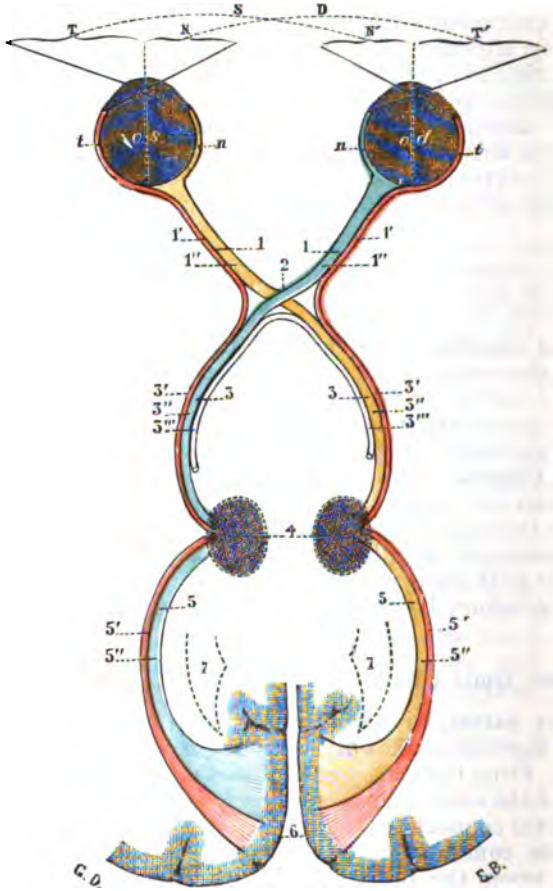


FIG. 578.—SCHEME INDICATING THE COURSE OF THE OPTIC NERVE-FIBRES FROM THE RETINA TO THE CEREBRAL CORTEX (L. TESTUT'S 'ANATOMIE HUMAINE').

o.s. Left Eye
o.d. Right Eye
t. Temporal Zone of Retina
n. Nasal Zone of Retina
T.N. Temporal and Nasal Portions of the Field of Vision for the Left Eye
T'N'. The corresponding portions of the Right Eye
D. The Right Half, and S, the Left Half, of the Field of Vision

1. Optic Nerve
1'. Its Direct Fibres (in red)
1''. Its Crossed Fibres (in yellow on left side, and blue on right side)
2. Optic Commissure
3. Optic Tract
3'. Direct Fibres of Optic Tract
3''. Crossed Fibres of Optic Tract
3'''. Commissure of Gudden
4. Nuclei of Interruption
5. Optic Radiation
5'. Direct Fibres
5''. Crossed Fibres
6. Cerebral Cortex (Mesial Aspect of Occipital Lobe)
7. Posterior Cornu of Lateral Ventricle

arise in the temporal or outer half of the retina take no part in the decussation, but pass directly backwards into the optic tract of the same side.

Occupying the back part of the commissure there are, as stated, some fibres which have no connection with either retina. These fibres constitute the **commissure of Gudden.** They lie behind the decussating fibres, and represent the fibres of the inner root of the optic tract of each side. They constitute the innermost fibres of each optic tract, and they connect the internal geniculate body of one side with its fellow of the opposite side.

Summary.—The fibres which arise in the nasal or inner half of one retina cross in the optic commissure, and enter the optic tract of the opposite side. The fibres which arise in the temporal or outer half of one retina pass directly backwards into the optic tract of the same side. The fibres of the inner root of each optic tract cross in the back part of the commissure, and form the commissure of Gudden, the fibres of which have no connection with the optic nerves, but connect the two internal geniculate bodies, right and left. The optic commissure therefore consists of the following groups of fibres: (1) The **crossed fibres,** which arise in the nasal or inner portion of each retina; (2) the **uncrossed fibres,** which arise in the temporal or outer portion of each retina, and occupy the outer part of the commissure; and (3) the fibres of the commissure of Gudden, which occupy the back part of the commissure.

The **optic tract** of each side is a flattened white band which passes backwards from the optic commissure. It curves round the crus cerebri, and in the region of the posterior extremity of the optic thalamus it divides into two roots, outer and inner. The **outer** or **visual root** is the larger of the two. It is chiefly composed of afferent fibres, which pass from the retina to the brain; but it also contains efferent fibres, which pass from the brain to the retina. The afferent fibres are derived from (1) the temporal or outer half of the retina of the same side, and (2) the nasal or inner half of the retina of the opposite side, the latter having crossed in the optic commissure. The fibres of the outer root terminate in the external geniculate body, the pulvinar of the optic thalamus, and the upper quadrigeminal body, reaching the last-named body through the superior brachium. They form arborizations around the cells of these bodies which constitute the terminal nuclei or *lower visual centres* of the outer or visual root. These lower visual centres are connected with the higher or cortical visual centre by the strand of fibres forming the **optic radiation,** the higher visual centre being situated in the cortex of the cuneate and lingual gyri of the mesial surface of the occipital lobe. The **inner** or **commissural root** of the optic tract passes beneath the internal geniculate body, which represents the nucleus of most of its fibres. As stated, these fibres have no connection with the optic nerve. Having traversed the inner part of the optic tract, they cross in the back part of the optic commissure, behind the decussating fibres, and are continuous with the corresponding fibres of the opposite side. These are the fibres which constitute the commissure of Gudden.

Summary of the Optic Tract.—The outermost fibres of each optic tract form the outer portion of the optic nerve of the same side. Most of the other fibres cross in the optic commissure, and form the inner portion of the optic nerve of the opposite side. The innermost fibres cross in the back part of the optic commissure, and form the commissure of Gudden.

Optic Radiation.—The strand of fibres which forms the optic radiation connects the lower visual centres with the higher or cortical visual centre. The fibres are both centripetal and centrifugal. After emerging from the external geniculate body, the pulvinar of the optic thalamus, and the upper quadrigeminal body, the fibres traverse the postlenticular part of the internal capsule. They then pass backwards into the white substance of the occipital lobe, where they lie on the outer surface of the posterior cornu of the lateral ventricle, from which they are separated by fibres of the tapetum. From this region they pass in a radiating manner to the higher or cortical visual centre in the cortex of the occipital lobe, more particularly the cortex of the cuneate and lingual gyri, close to the calcarine fissure on the mesial surface of the lobe.

The lower visual centres are regarded as being connected with the nuclei of origin of the nerves which supply the ocular muscles, probably through means of the posterior longitudinal bundle.

Mesencephalon.

The mesencephalon is composed of the corpora quadrigemina, which form its upper or dorsal portion; the crura cerebri, which form its lower or ventral portion; and the aqueduct of Sylvius, which passes through it from the fourth ventricle below to the third ventricle above.

Corpora Quadrigemina.—These are four rounded eminences, which, as just stated, form the dorsal portion of the mesencephalon. They are covered by the splenium of the corpus callosum, and are arranged in pairs, upper and lower, the upper pair (*nates*) being larger than the lower pair (*testes*), but not quite so prominent. The four eminences are separated from each other by two grooves, longitudinal and transverse, which are arranged in a crucial manner. The longitudinal groove extends upwards as far as the posterior commissure, and it separates the upper and lower quadrigeminal bodies of one side from those of the other side. Its upper part lodges the pineal body, and from its lower part a band of white fibres, called the *frenulum veli*, passes downwards to the superior medullary velum or valve of Vieussens, which lies below the lower pair of eminences. The transverse groove separates the upper pair of quadrigeminal bodies from the lower pair. Laterally each eminence is connected with a white band, called the **brachium**, the two brachia being separated by a continuation of the transverse groove.

The **superior brachium** extends outwards and forwards from the

upper quadrigeminal body to the external geniculate body and the outer root of the optic tract. It passes between the pulvinar of the optic thalamus and the internal geniculate body.

The superior brachium contains two sets of fibres, namely, **retinal fibres,** derived from the outer root of the optic tract, and (2) **occipital fibres,** from the cortex of the occipital lobe of the cerebrum.

The **inferior brachium** passes upwards from the lower quadrigeminal body to the under aspect of the internal geniculate body, which is a small oval mass on the lateral aspect of the mesencephalon, under cover of the pulvinar of the optic thalamus.

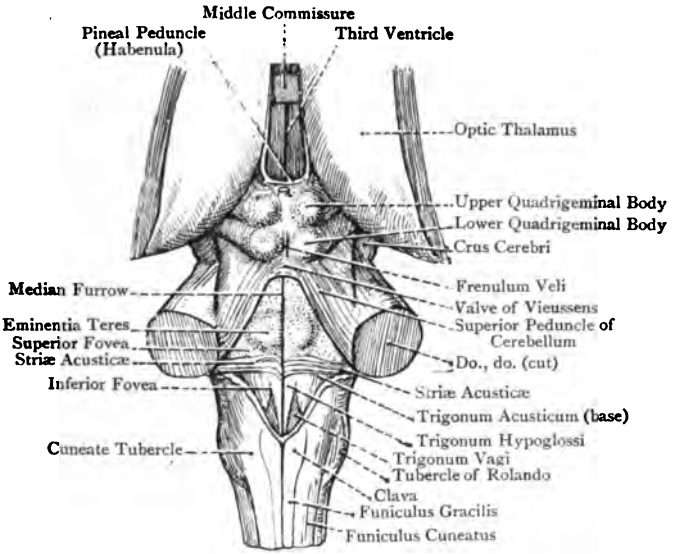


FIG. 579.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS.

Though the inner root of the optic tract is connected with the internal geniculate body, the inferior brachium passes clear of it, and the most of its fibres are traceable to the optic thalamus through the tegmentum.

Structure.—The **lower quadrigeminal body,** of each side, is composed of a central nucleus of grey matter, which is almost completely surrounded by white fibres. The nucleus contains many multipolar cells, and is traversed by delicate fibres, which are derived from the inferior brachium and the lateral fillet, some fibres of the latter being also disposed superficially. The fibres of the lateral fillet are derived from the corpus trapezoides of the pons Varolii, and have crossed from the opposite side, where they are connected with the central nucleus of the cochlear division of the auditory nerve. The lower quadrigeminal body is therefore to be regarded as associated with the auditory apparatus.

The **upper quadrigeminal body** is composed of four layers, namely, the stratum zonale, stratum cinereum, stratum opticum, and stratum lemnisci.

The **stratum zonale** is placed superficially, and is composed of white retinal fibres, which are derived from the outer root of the optic tract. The **stratum cinereum** lies beneath the stratum zonale, and consists of a crescentic layer of grey matter. The third layer or **stratum opticum** consists of grey matter and occipital fibres, the latter being derived from the cortex of the occipital lobe of the cerebrum. The last layer, or **stratum lemnisci,** like the stratum opticum, is composed of grey matter and fibres, the latter being derived from the fillet.

The upper quadrigeminal body is one of the three lower visual centres, the other two being the external geniculate body and the pulvinar of the optic thalamus. It derives its fibres from (1) the fillet, which enters the stratum lemniscum, and (2) the superior brachium, which, as stated, consists of

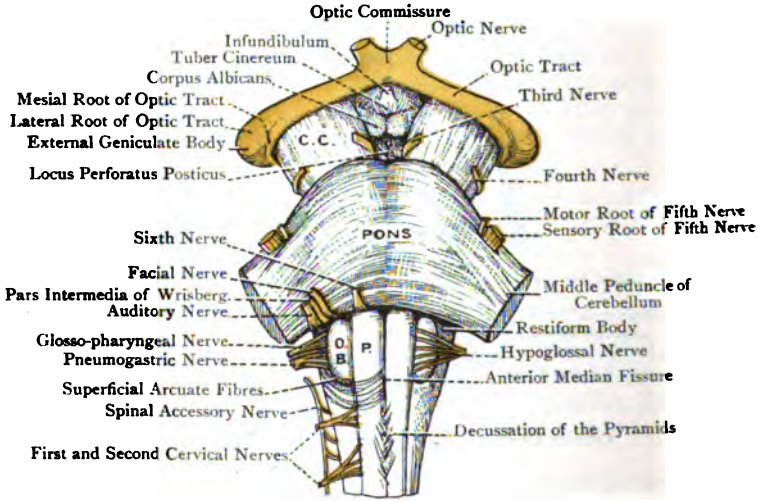


FIG. 580.—THE MEDULLA OBLONGATA, PONS VAROLII, AND INTERPEDUNCULAR REGION.

C.C., Crus Cerebri ; P., Pyramid ; O.B., Olivary Body.

(*a*) retinal fibres, from the outer root of the optic tract, and (*b*) occipital fibres, from the higher or cortical visual centre in the cortex of the occipital lobe of the cerebrum.

Development.—The corpora quadrigemina are developed as thickenings of the dorsal wall of the mesencephalon.

Commissure of Meynert.—This commissure or decussation consists of fibres which issue from each upper quadrigeminal body and cross to the opposite posterior longitudinal bundle, in which they descend towards the pons Varolii.

Corpus Geniculatum Internum.—This is a small oval mass, which is situated on the lateral aspect of the mesencephalon, under cover of the pulvinar of the optic thalamus. It receives the fibres of the inner root of the optic tract, and, through means of the com-

missure of Gudden, the right and left internal geniculate bodies are connected with each other. The inferior brachium from the lower quadrigeminal body passes beneath it on its way to the optic thalamus.

Development.—The corpus geniculatum internum appears as an elevation on the lateral wall of the thalamencephalon or diencephalon.

Crura Cerebri.—The crura cerebri form the ventral portion of the mesencephalon. They are two in number, right and left, and emerge from the upper part of the pons Varolii, lying at first close together, but afterwards diverging, as they pass upwards and outwards to enter the cerebral hemispheres. The inner surface of each crus presents a furrow, called the *oculo-motor sulcus*, from which the fasciculi of the third cranial or oculo-motor nerve emerge just above the pons Varolii; and the fourth cranial nerve lies on its outer surface. At the place where the crus enters the cerebral hemisphere it is embraced externally by the optic tract.

Each crus is composed of two parts, dorsal and ventral. The *dorsal* portion is called the **tegmentum,** and the *ventral* portion is known as the **crusta** or **pes.** These two parts are separated from each other in the interior by a mass of dark grey matter, called the **substantia nigra.** The separation between them externally is indicated on either side by a groove. The groove on the outer aspect of the crus is known as the *lateral sulcus*, and that on the inner surface as the *oculo-motor sulcus*, from the fact that the fasciculi of the oculo-motor nerve emerge through it. The upward prolongation of the tegmentum constitutes the subthalamic tegmental region, and it consists of centripetal fibres which are ascending to the cerebral cortex. The crusta becomes continuous with the internal capsule, and consists of centrifugal fibres which are descending from the cerebral cortex.

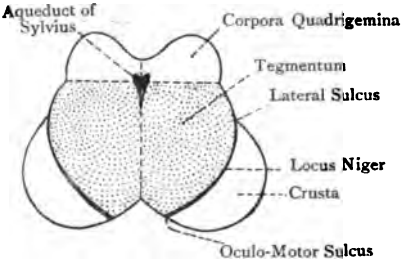


FIG. 581.—TOPOGRAPHY OF THE CRUS CEREBRI (AFTER POIRIER).

Internal Structure of the Crus Cerebri—Tegmentum.—This consists of longitudinal fibres, intersected by transverse fibres, with a large admixture of grey matter in the intervening spaces. It is an upward prolongation of the formatio reticularis of the dorsal portion of the pons Varolii. The two tegmenta, right and left, are intimately connected in the lower part of the mesencephalon, in which situation the two superior cerebellar peduncles decussate. Each tegmentum contains four tracts, namely, (1) the superior cerebellar peduncle, (2) the posterior longitudinal bundle, (3) the lateral fillet, and (4) the mesial fillet.

Superior Cerebellar Peduncle.—The fibres of this peduncle emerge, for the most part, through the hilum of the nucleus den-

tatus in the cerebellar hemisphere, but some arise from the cerebellar cortex. Underneath the lower pair of quadrigeminal bodies, and on the ventral aspect of the Sylvian aqueduct, the fibres of the two peduncles decussate in the tegmenta. Each bundle, having crossed to the opposite side, enters the upper part of the tegmentum, and comes into contact with a collection of grey matter which has a reddish colour, and is known as the red nucleus. Many of the fibres of the peduncle terminate in this nucleus, but others pass around it, and are continued into the optic thalamus, and, it may be, through it to the cerebral cortex. From the cells of the red nucleus fresh fibres proceed to the optic thalamus; and from the thalamic cells another set of fibres arise which pass to the cerebral cortex, more particularly the cortex of the ascending parietal or postcentral convolution, which lies directly behind the fissure of Rolando. The superior cerebellar peduncle of one side, therefore, connects the cerebellar hemisphere of that side with the Rolandic region of the cerebral cortex of the opposite side, more particularly the post-Rolandic cortex, the red nucleus and the optic thalamus being interposed in the course of most of its fibres.

The **red nucleus,** or **nucleus of the tegmentum,** is a round, reddish mass of grey matter, which is situated in the upper part of the tegmentum in the course of the fibres of the superior cerebellar peduncle of the opposite side. As just stated, many of the fibres of the opposite superior cerebellar peduncle terminate in connection with its cells, and the axons of these cells constitute a fresh set of fibres which carry on the superior cerebellar peduncle to the optic thalamus. The red nucleus is traversed by the fibres of the third cranial nerve, and it is prolonged into the subthalamic tegmental region.

Posterior Longitudinal Bundle.—This bundle is related to the dorsal aspect of the tegmentum, and lies on the ventral aspect of the aqueduct of Sylvius. It is situated close to the median line, and in intimate relation with its fellow of the opposite side. Inferiorly it is continuous with the anterior ground-bundle of the spinal cord, and, after passing through the medulla oblongata and the pons Varolii, it traverses the entire length of the tegmentum as high as the subthalamic tegmental region. In this situation its fibres are regarded as arising from a special nucleus in the grey matter of the floor of the third ventricle, just inferior to the corpus albicans. The posterior longitudinal bundle is intimately related to the nuclei of origin of the nerves of the ocular muscles, namely, the third or oculo-motor nucleus, the fourth or trochlear nucleus, and the sixth or abducent nucleus. Each of these nuclei receives collaterals from the bundle, and probably one of the chief uses of the bundle is to maintain a functional association between these nuclei, and insure harmonious action on the part of the muscles which are supplied by the nerves arising from them.

The posterior longitudinal bundle of one side receives fibres from the upper quadrigeminal body of the opposite side. These fibres decussate with those

of the opposite side, and constitute the **commissure of Meynert.** Fibres from the third or oculo-motor nucleus are regarded as being conveyed by the posterior longitudinal bundle to the facial nerve, and thence to the orbicularis palpebrarum and corrugator supercilii muscles. According to this view these two muscles are under the control of the same nucleus as the levator palpebræ superioris. Fibres are said to be conveyed by the posterior longitudinal bundle from the sixth or abducent nucleus to that portion of the third or oculo-motor nucleus from which the nerve for the internal rectus muscle of the opposite side arises. This would explain the harmonious action of the external rectus of one side and the internal rectus of the other side in moving the eyeballs to one or other side simultaneously. Fibres may also pass from the hypoglossal nucleus through the posterior longitudinal bundle into the facial nerve, and thence to the orbicularis oris muscle. If this is so, the orbicularis oris and the muscles of the tongue would be under the control of the same nucleus.

Fillet.—There are two tracts with which the name of fillet is associated, namely, the lateral fillet and the mesial fillet.

The **lateral fillet** consists of fibres from the corpus trapezoides in the lower part of the pons Varolii. The sources from which these fibres are derived are as follows: (1) the terminal nuclei of the cochlear division of the auditory nerve of the same, and also of the opposite, side; and (2) the superior olivary nucleus. The lateral fillet ascends through the dorsal or tegmental portion of the pons towards the corpora quadrigemina, and its fibres terminate in (*a*) the lower quadrigeminal body, (*b*) the upper quadrigeminal body, and (*c*) the internal geniculate body.

The lateral fillet is associated with the auditory apparatus.

The **mesial fillet** commences in the lower part of the medulla oblongata, and derives its fibres from the nucleus gracilis and nucleus cuneatus of the opposite side. It is therefore the continuation upwards of the posterior column of the spinal cord. Having traversed the medulla and pons, it enters the tegmentum, and its fibres terminate as follows: (1) some enter the upper quadrigeminal body, and end in the stratum lemniscum; and (2) others pass through the subthalamic tegmental region and enter the optic thalamus, where they end in arborizations around the thalamic cells. From these cells fresh fibres pass to the cerebral cortex.

Crusta or **Pes.**—The crusta or pes is, as stated, the ventral portion of the crus cerebri, and it is separated from the tegmentum of the crus by a mass of dark grey matter, called the substantia nigra, which is situated in the interior. Externally the separation is indicated on the outer aspect by the lateral sulcus, and on the inner aspect by the oculo-motor sulcus, through which the fasciculi of the oculo-motor nerve emerge. The crusta is continuous with the internal capsule of the corpus striatum, and it consists of longitudinal centrifugal fibres, which arise in the cells of the cerebral cortex. These fibres are arranged in two sets, namely, pyramidal and cortico-pontine. The pyramidal fibres form the motor tract from the Rolandic region of the cerebral cortex; and the cortico-pontine fibres are arranged in two strands, namely, fronto-pontine and temporo-pontine.

The **pyramidal fibres** form the motor tract from the Rolandic region of the cerebral cortex. They traverse the lenticular portion of the posterior limb of the internal capsule, and then occupy the *middle three-fifths* of the crusta. Thereafter they descend through the ventral portion of the pons Varolii and the pyramid of the medulla oblongata. In the lower part of the pyramid they give rise to the crossed and direct pyramidal tracts. The crossed pyramidal tract, having taken part in the decussation of the pyramids, descends in the spinal cord, occupying the posterior part of the lateral column of the opposite side. The direct pyramidal tract descends in the spinal cord, occupying the inner portion of the anterior column of the same side, and forming the column of Türck. Its fibres, however, cross at intervals to the opposite side.

As the pyramidal tract descends through the pons Varolii and medulla oblongata, some of its fibres pass to the motor nuclei of the cranial nerves in these regions.

The **cortico-pontine** or **cortico-protuberantial fibres** are arranged in two strands, fronto-pontine and temporo-pontine. The fibres

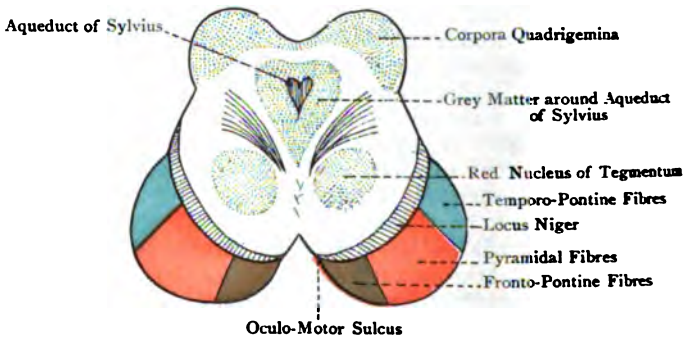


FIG. 582.—TRANSVERSE SECTION OF THE CRUS CEREBRI (AFTER POIRIER).

of the **fronto-pontine strand** arise from the cells of the cortex of the anterior part of the frontal lobe, and, having traversed the anterior limb of the internal capsule, they are regarded as occupying the *inner fifth* of the crusta. The fibres of the **temporo-pontine strand** arise from the cells of the cortex of the temporal lobe, and, having traversed the postlenticular part of the internal capsule, they occupy the *outer fifth* of the crusta. In the ventral part of the pons both the fronto-pontine and the temporo-pontine fibres terminate in arborizations around the cells of the nucleus pontis, whereas the pyramidal fibres pass uninterruptedly through the ventral part of the pons.

Summary of the Crusta.—The crusta is divided into three parts. The middle three-fifths contain the fibres of the pyramidal or motor tract, the inner fifth probably contains the fibres of the fronto-pontine strand, and the outer fifth contains the fibres of the temporo-pontine strand.

Substantia Nigra.—This is a mass of dark grey matter which is situated between the tegmentum and the crusta of the crus cerebri. Like the crusta, it is semilunar or crescentic, as seen in transverse section. It contains many multipolar nerve-cells, which are deeply pigmented, and it extends from the upper border of the pons Varolii into the subthalamic tegmental region. Laterally it reaches the lateral sulcus on the outer aspect of the crus, where it is thin, and the oculo-motor sulcus on the inner aspect, where it is thick and is traversed by the fasciculi of the third cranial or oculo-motor nerve. Its tegmental surface is concave, and the surface directed towards the crusta is convex. From the latter surface prolongations extend into the crusta.

The substantia nigra is said to be connected with the nucleus caudatus of the corpus striatum by a tract of fibres, called the *stratum intermedium*. The significance of the substantia nigra is not known.

Summary of the Crura Cerebri.—The crura cerebri form the ventral portion of the mesencephalon. Each crus is composed of two parts—dorsal and ventral. The dorsal portion is called the tegmentum, and the ventral portion is called the crusta or pes. The separation between these parts externally is indicated by the lateral sulcus on the outer aspect, and the oculo-motor sulcus on the inner aspect. The internal separation is effected by the substantia nigra. The two tegmenta, right and left, are intimately connected in the lower part of the mesencephalon, in which situation the superior cerebellar peduncles decussate, but the two crustæ are quite distinct from each other. Each **tegmentum** contains three tracts, namely, (1) the superior cerebellar peduncle, (2) the posterior longitudinal bundle, and (3) the fillet.

The two **superior cerebellar peduncles** decussate beneath the lower pair of quadrigeminal bodies, and on the ventral aspect of the Sylvian aqueduct. The fibres of each peduncle, having crossed, partly terminate in the red nucleus in the upper part of the tegmentum, and partly pass around it, and are continued into the optic thalamus. From the cells of the red nucleus fresh fibres arise and pass to the optic thalamus, and from the thalamic cells another set of fibres arise which pass to the cerebral cortex, more particularly the cortex of the ascending parietal or postcentral convolution. The superior cerebellar peduncle of one side, therefore, connects the cerebellar hemisphere of that side with the Rolandic region of the cerebral cortex of the opposite side, more particularly the post-Rolandic cortex, the red nucleus and the optic thalamus being interposed in the course of most of its fibres. The **red nucleus** is situated in the upper part of the tegmentum in the path of the fibres of the superior cerebellar peduncle of the opposite side, for which it acts as a cell-station.

The **posterior longitudinal bundle** is continuous with the anterior ground-bundle of the spinal cord. Its chief significance consists in its intimate relation to the nuclei of origin of the third or oculo-motor, fourth or trochlear, and sixth or abducent nerves, to each of which nuclei it furnishes collaterals. Probably one of the chief uses of the bundle is to maintain a functional association between these nuclei, and insure harmonious action on the part of the muscles which are supplied by the nerves arising from them.

The **fillet** constitutes two tracts, lateral and mesial. The **lateral fillet** consists of fibres from the corpus trapezoides, and these ultimately come from (1) the terminal nuclei of the cochlear division of the auditory nerve of the same side, and also of the opposite side; and (2) the superior olivary nucleus. The fibres of the lateral fillet pass to (*a*) the lower quadrigeminal body, (*b*) the upper quadrigeminal body, and (*c*) the internal geniculate body. The lateral fillet is associated with the auditory apparatus.

The **mesial fillet** derives its fibres from the nucleus gracilis and nucleus cuneatus of the opposite side, and it is a continuation upwards of the posterior column of the spinal cord. Its fibres pass to (1) the stratum lemniscum of the upper quadrigeminal body, and (2) the optic thalamus, from the cells of which fresh fibres proceed to the cerebral cortex.

The **crusta** or **pes** is divided into three parts. The middle three-fifths contain the fibres of the pyramidal or motor tract; the inner fifth probably contains the fibres of the fronto-pontine strand; and the outer fifth contains the fibres of the temporo-pontine strand.

The **substantia nigra** is situated between the tegmentum and the crusta. Its significance is not known.

Development.—The crura cerebri are developed as thickenings of the ventral wall of the mesencephalon.

Aqueduct of Sylvius.—The aqueduct of Sylvius is the narrow passage which leads through the mesencephalon from the third to the fourth ventricle (*iter a tertio ad quartum ventriculum*). It lies nearer the dorsal than the ventral aspect of the mesencephalon; its direction is from above downwards; and its length is rather more than ½ inch. Its upper opening is situated on the posterior boundary of the third ventricle, immediately underneath the posterior commissure, and its lower opening occupies the superior median angle of the floor of the fourth ventricle. In transverse section the aqueduct is T-shaped in its upper part, near the third ventricle, and triangular in its lower part, near the fourth ventricle. The passage is lined with ciliated columnar epithelium, external to which there is a thick layer of grey matter, which is spoken of as the **Sylvian grey matter.** This is continuous superiorly with the grey matter of the floor and lateral walls of the third ventricle, and inferiorly with that which covers the floor of the fourth ventricle. It contains numerous nerve-cells, disposed in a scattered manner, but, in addition to these, there are certain definite cell-groups. These groups constitute the nuclei of origin of the following cranial nerves: the third or oculo-motor, the fourth or trochlear, and the descending or mesencephalic root of the fifth nerve. The **oculo-motor nucleus** is situated in the ventral portion of the Sylvian grey matter, underneath the upper quadrigeminal body, and it extends upwards into the layer of grey matter on the adjacent portion of the lateral wall of the third ventricle. The **trochlear nucleus** is also situated in the ventral portion of the Sylvian grey matter, but at a lower level than the oculo-motor nucleus, being placed underneath the upper part of the lower quadrigeminal body. The **nucleus of the descending or mesencephalic root of the fifth nerve** is extensive, and is situated in the lateral portion of the Sylvian grey matter.

Development.—The aqueduct of Sylvius is the persistent remains of the cavity of the mesencephalon.

Structure of the Cerebral Hemispheres.

The cerebral hemisphere is composed of grey and white matter. The grey matter is disposed externally, and forms the cerebral *cortex*. The white matter occupies the interior, and constitutes the *medullary centre*.

Cerebral Cortex.—The grey matter forms a continuous covering to the entire hemisphere, dipping into the sulci, so as to cover the opposed surfaces of the gyri, as well as the bottom of the sulci. It is thicker over the superficial surfaces of the gyri than at the bottom of the sulci, and attains its greatest thickness over the upper portions of the precentral and postcentral gyri, whilst it is thinnest over the occipital lobe. It is the seat of the intellectual and psychical functions, and of consciousness.

The cerebral cortex differs in structure in different regions; but it has certain general characters, which will be now described. It is essentially laminated or stratified, and is composed of superimposed layers of white and grey matter, alternating with each other, these being for the most part four in number, but in some places there are as many as six, *e.g.*, over the precentral gyrus. From without inwards these six layers are disposed as follows: (1) a narrow layer of white matter on the surface; (2) a layer of grey matter; (3) a second narrow layer of white matter, called the **outer band of Baillarger** (band of Vicq d'Azyr); (4) a second layer of grey matter; (5) a third narrow layer of white matter, called the **inner band of Baillarger**; and (6) a third layer of grey matter, which is in close contact with the white matter of the medullary centre. In those regions where there are only four layers, No. 5 cannot be seen, and Nos. 4 and 6 are combined into one layer.

Minute Structure of the Cerebral Cortex.—The cortex is composed of nerve-cells and nerve-fibres.

Nerve-cells.—These are arranged in four layers, which are as follows from without inwards: (1) the molecular layer; (2) the layer of small pyramidal cells; (3) the layer of large pyramidal cells; and (4) the layer of polymorphous cells.

The **molecular layer** (*stratum zonale*), which is the most superficial, is narrow, and is principally composed of tangential fibres, which are disposed horizontally or parallel to the surface of the gyri. The nerve-cells are small, chiefly fusiform, and situated in the deep part of the layer. They lie with their long axes parallel to the surface, and each gives off from either pole a long slender dendrite. These dendrites mingle with the tangential fibres, and give off branches which are directed towards the surface. Besides fusiform cells there are a few triangular cells, each of which sends off dendrites, and one of these becomes the axon of a nerve-fibre.

The **pyramidal layers** represent the second and third layers, and are composed of characteristic pyramidal cells which are peculiar to the cerebral cortex, those of the second layer being small, whilst those of the third layer are large. The layer of small pyramidal

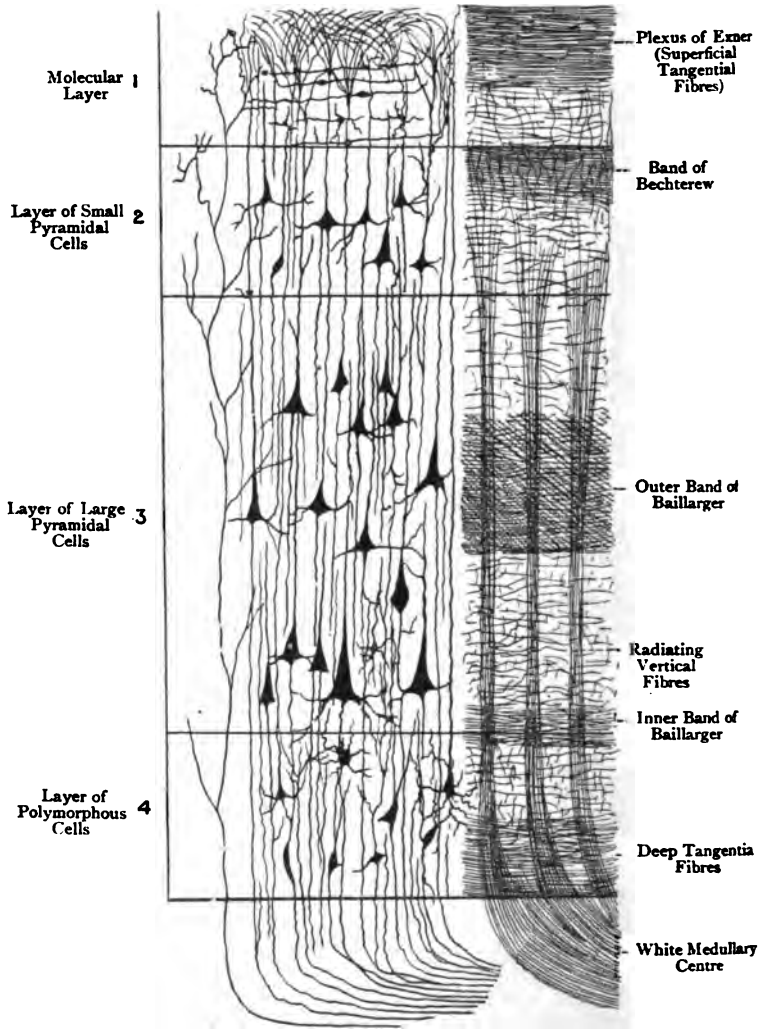

Molecular Layer 1
Layer of Small Pyramidal Cells 2
Layer of Large Pyramidal Cells 3
Layer of Polymorphous Cells 4
Plexus of Exner (Superficial Tangential Fibres)
Band of Bechterew
Outer Band of Baillarger
Radiating Vertical Fibres
Inner Band of Baillarger
Deep Tangentia Fibres
White Medullary Centre

FIG. 583.—DIAGRAM SHOWING THE MINUTE STRUCTURE OF THE CEREBRAL CORTEX (POIRIER).

The Fibres are shown on the right, and the Cells on the left.

cells is narrow, but the layer of large pyramidal cells is of considerable thickness. There is no well-marked line of demarcation between these two layers, the one passing imperceptibly into the other. They constitute the chief part of the cerebral cortex.

The apex of each **pyramidal cell** is directed towards the surface of the gyrus, and is prolonged into a long tapering dendrite, which passes into the molecular layer, giving off delicate collaterals in its course. Near the surface of the molecular layer it divides into terminal filaments, which are disposed horizontally and mingle with the tangential fibres. The base of the pyramidal cell is directed towards the medullary centre of the gyrus, and from its centre an axon is given off, which enters the medullary centre, giving off collaterals in its course. From each side of the body of the cell, as well as from each lateral angle of its base, dendrites are given off.

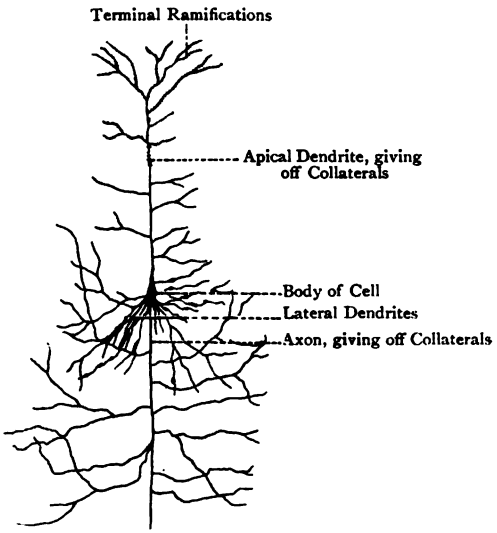


FIG. 584.—A PYRAMIDAL CELL OF THE HUMAN CEREBRAL CORTEX (RAMON Y CAJAL).

The **polymorphous layer** is the deepest layer, and is composed of cells which have different shapes. Each cell gives off several dendrites, which pass towards, but do not enter, the molecular layer. The axon of each cell enters the medullary centre as a nerve-fibre.

In addition to the foregoing cells of the cerebral cortex, two other kinds of cells are met with amongst the pyramidal and polymorphous cells, namely, the cells of Golgi and the cells of Martinotti. The **cells of Golgi** are characterized by the fact that the axon of each almost immediately divides into several branches, which pass towards the surface, but soon terminate without entering the molecular layer. The **cells of Martinotti** are chiefly met with in the polymorphous layer. The axon of each cell passes towards the surface, and enters the molecular layer, where it divides into terminal branches, which form part of the tangential fibres of this layer.

Nerve-fibres of the Cortex.—These are arranged in two groups—vertical and tangential.

The **vertical** (radial) **fibres** are disposed in radiating bundles,

which issue from the medullary centre, and traverse the polymorphous and large pyramidal layers, after which they become indistinguishable. The polymorphous and large pyramidal cells lie in the spaces between these bundles, and assume a columnar arrangement. The fibres of the radiating bundles gradually become less numerous, some of them becoming the axons of the polymorphous cells, but most of them becoming the axons of the large pyramidal cells. The radiating bundles contain centripetal cortical fibres, which pass into the molecular layer and end in terminal ramifications, forming part of its tangential fibres.

The **tangential fibres** are disposed horizontally at different levels, and form the following strata: (1) the **superficial tangential fibres (plexus of Exner),** which occupy the superficial part of the molecular layer; (2) the **band of Bechterew,** which is situated in the superficial part of the small pyramidal layer; (3) the **outer band of Baillarger** (*band of Vicq d'Azyr*), which intersects the large pyramidal layer; (4) the **inner band of Baillarger,** which is situated between the large pyramidal and polymorphous layers; and (5) the **deep tangential fibres** (*intra-cortical association fibres*), which are situated in the deep part of the polymorphous layer.

The tangential fibres are formed by (1) the collaterals of the polymorphous and pyramidal cells and of the cells of Martinotti; (2) the ramifications of the axons of the cells of Golgi; and (3) association fibres.

Medullary Centre of the Cerebral Hemisphere.—The white matter of the medullary centre consists of medullated nerve-fibres, arranged in bundles, with neuroglia between them. The fibres pursue different courses, and are arranged in three groups, namely, projection fibres, commissural fibres, and association fibres.

Projection Fibres.—The most of these fibres are traceable through the corona radiata into the internal capsule of the corpus striatum, but some of them pass through the lenticular nucleus and external capsule. Beyond these regions they are continued into the crusta and tegmentum of the crus cerebri. The projection fibres therefore connect the cerebral cortex with the parts below. They consist of centripetal (afferent) and centrifugal (efferent) fibres.

The **centripetal fibres** are as follows: (1) thalamic fibres, which arise within the optic thalamus as the axons of its cells, and which form the thalamic radiation; (2) fibres of the superior cerebellar peduncle, which have passed over the red nucleus and through the optic thalamus on their way to the cortex of the Rolandic region of the cerebral hemisphere; (3) a few of the fibres of the fillet, which have passed through the optic thalamus on their way to the cortex of the postcentral gyrus; (4) fibres of the optic radiation, proceeding to the occipital cortex; and (5) fibres of the auditory radiation, proceeding to the temporal cortex.

The **centrifugal fibres** are as follows: (1) The **pyramidal fibres,** which proceed from the cortex of the Rolandic region. Having traversed the corona radiata, these fibres pass, in succession, through

(*a*) the posterior limb of the internal capsule ; (*b*) the middle three-fifths of the crusta of the crus cerebri ; (*c*) the ventral portion of the pons Varolii ; (*d*) the pyramid of the medulla oblongata, and thence into the spinal cord, partly as the direct pyramidal tract or column of Türck, but chiefly as the crossed pyramidal tract. Ultimately the fibres terminate, at different levels in the spinal cord, in arborizations around the anterior cornual cells, from which the fibres of the anterior or motor nerve-roots proceed. (2) The **fronto-pontine tract,** which consists of fibres proceeding from the cortex of the frontal region in front of the precentral sulcus. These fibres reach the ventral portion of the pons Varolii through the anterior limb of the internal capsule, and probably through the inner or mesial fifth of the crusta of the crus cerebri. In the pons they terminate in arborizations around the cells of the nucleus pontis. (3) The **temporo-pontine tract,** the fibres of which proceed from the temporal cortex through the postlenticular part of the posterior limb of the internal capsule and the outer fifth of the crusta, to the ventral portion of the pons, where they end in arborizations around the cells of the nucleus pontis. (4) The **optic radiation,** the fibres of which pass from the occipital cortex through the postlenticular part of the posterior limb of the internal capsule to the external geniculate body, pulvinar, and upper quadrigeminal body.

Commissural Fibres.—These fibres are disposed transversely, and serve to connect the grey cortex of one hemisphere with that of the other. They constitute the following commissures : (1) the corpus callosum ; (2) the anterior commissure ; and (3) the lyra or psalterium, which is known as the hippocampal commissure. The fibres of the **corpus callosum,** as they enter each hemisphere, are disposed so as to form an extensive **callosal radiation,** and serve to connect the cortex of one hemisphere with that of the other. The individual portions of cortex so connected may be symmetrical, but to a large extent they are asymmetrical. The fibres arise on one side as (1) the axons of pyramidal or of polymorphous cells, or (2) collaterals of projection or of association fibres ; and on the opposite side they terminate in delicate arborizations.

The **anterior commissure,** which crosses from side to side in front of the anterior pillars of the fornix, divides on either side into two parts, olfactory and temporal. The *olfactory portion* enters the olfactory tract. Some of its fibres serve to connect the olfactory bulb of one side with that of the other side ; and other fibres connect the olfactory bulb of one side with the temporal lobe of the opposite. The *temporal portion* enters the white matter of the temporal lobe on either side.

The **lyra** or **psalterium** consists of transverse fibres which connect the hippocampus major of one side with its fellow of the opposite side ; hence the name **hippocampal commissure.**

Association Fibres.—These fibres serve to connect different parts

of the cortex of the same hemisphere, and they are of two kinds, short and long.

The **short association fibres** pass between contiguous gyri, extending in their course across the bottom of the sulci. Some of them lie beneath the grey cortex, whilst others are contained within its deep part.

The **long association fibres** pass between portions of the grey cortex, which are at some distance from each other. They are arranged in bundles, the chief of which are as follows: (1) the superior longitudinal fasciculus; (2) the inferior longitudinal fasciculus; (3) the perpendicular fasciculus; (4) the uncinate fasciculus; (5) the cingulum; (6) the occipito-frontal fasciculus; and (7) the fornix.

The **superior longitudinal fasciculus** consists of fibres which extend from the frontal to the occipital lobe. Posteriorly many of its fibres sweep downwards and forwards into the temporal lobe, and from this circumstance it is sometimes spoken of as the **arcuate fasciculus.**

The **inferior longitudinal fasciculus** connects the occipital and temporal lobes, its fibres being disposed upon the outer walls of the posterior and descending cornua of the lateral ventricle.

The **perpendicular fasciculus** connects the inferior parietal gyrus with the occipito-temporal gyrus.

The **uncinate fasciculus** crosses the stem of the fissure of Sylvius, and connects the frontal and temporal lobes.

The **cingulum** is connected with the limbic lobe, and lies upon the under surface of the callosal gyrus and the upper surface of the hippocampal gyrus. Its fibres connect the gyri of the limbic lobe with the cerebral cortex.

The **occipito-frontal fasciculus** connects the frontal with the occipital and temporal lobes. According to Dejerine the *tapetum* of the corpus callosum belongs to this fasciculus, and not to the corpus callosum. The fasciculus lies internal to the corona radiata, in intimate relation to the nucleus caudatus, and, as the fibres pass backwards, they lie on the outer walls of the descending and posterior cornua of the lateral ventricle.

The **fornix** connects the hippocampus major of one side with the corresponding corpus albicans, and, through the latter, with the optic thalamus by means of the bundle of Vicq d'Azyr, the fibres of which arise in the corpus albicans.

Peculiarities of the Cerebral Cortex—1. **Calcarine Area.**—This area is situated on the mesial surface of the occipital lobe, in close proximity to the calcarine fissure, and it is known as the **visual area.** In this region the outer band of Baillarger is very conspicuous, whilst the inner band of Baillarger is absent.

2. **Rolandic Area.**—In this region, more especially in the cortex of the precentral gyrus, there are groups of very large pyramidal cells, which are known as the **giant-cells of Betz,** and nerve-fibres are present in large numbers.

3. **Hippocampal Area.**—The hippocampus major corresponds to the hippocampal or dentate fissure, and is produced by an infolding of the cerebral

cortex. It is therefore composed chiefly of grey matter, and is covered superficially by a thin layer of white matter, called the **alveus,** which is continuous with the fimbria. The hippocampus major is composed of the following layers, named in order from the ventricular surface outwards: (1) the **alveus,** composed of white matter, and covered by the ventricular ependyma; (2) **neuroglial layer,** consisting of neuroglia fibres and cells; (3) **pyramidal layer,** composed of large pyramidal cells; (4) **stratum radiatum,** which is the outer part of the pyramidal layer, and is composed of the dendrites of the apical parts of the pyramidal cells, being thereby rendered striated in appearance; (5) **stratum lacinlosum,** composed of the ramifications of the foregoing apical dendrites, intimately intermixed; (6) **stratum granulosum,** composed of many small cells; and (7) the **involuted medullary lamina,** consisting of white fibres.

Olfactory Tract and Olfactory Bulb.—These are developed as a hollow outgrowth from the anterior cerebral vesicle, more particularly from the part of it which ultimately gives rise to the lateral ventricle, and is known as the **telencephalon.** In many animals the central cavity persists, and maintains its connection with the lateral ventricle; but in man the cavity disappears, though traces of its ependymal lining remain. External to the vestigial ependyma there is a layer of white matter, and, superficial to this, there is a layer of grey matter. In the **olfactory tract** the layer of grey matter is very thin over the ventral or inferior aspect, but over the dorsal or superior aspect it is fairly thick. In the **bulb** the reverse is the case, the grey matter being thick over the ventral aspect, where it receives the olfactory filaments, but thin over the dorsal aspect.

Structure of the Ventral Grey Matter of the Olfactory Bulb.—The grey matter consists of three layers, namely (1) the nerve-fibre layer, (2) the glomerular layer, and (3) the granular layer.

The **nerve-fibre layer** is the most superficial layer, and is composed of olfactory nerve-fibres. These fibres are non-medullated, and arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa. Having passed through the foramina of one half of the cribriform plate of the ethmoid bone, they enter the grey matter on the ventral aspect of the bulb, where they break up and form arborizations. These intermingle with the arborizations formed by the dendrites of the mitral cells, to be presently described.

The **glomerular layer** is composed of round bodies or *glomeruli,* which are formed by the interlacements between the arborizations of the olfactory nerve-fibres and those of the dendrites of the mitral cells.

The **granular layer** lies next to the layer of white matter, and is chiefly characterized by the presence of large **mitral cells.** These are pyramidal, and one dendrite from each cell passes into the glomerular layer, where it gives rise to a glomerulus in the manner just described in connection with the glomerular layer. Other dendrites intermingle with those of adjacent mitral cells. The axon of each mitral cell enters the white layer of the bulb, and passes along the olfactory tract to the cerebrum.

Weight of the Brain.—The average weight of the brain of the adult male is about 48 ounces, and that of the adult female about 44 ounces.

Arteries of the Encephalon.

Cerebral Part of the Internal Carotid Artery.—The internal carotid artery, having pierced the roof of the cavernous sinus, internal to the anterior clinoid process of the sphenoid bone, ascends between the second and third cranial nerves to the inner end of the stem of the fissure of Sylvius. Here it divides into its terminal branches, namely, anterior cerebral and middle cerebral.

Branches.—These are as follows: posterior communicating anterior choroidal, anterior cerebral, and middle cerebral.

The **posterior communicating artery** arises from the back part of the internal carotid, and passes backwards to anastomose with the posterior cerebral artery. It is usually of small size, but is occasionally large, and it furnishes twigs to the crus cerebri and inner aspect of the optic thalamus.

The **anterior choroidal artery** arises from the back part of the internal carotid close to its termination. It passes backwards and outwards between the crus cerebri and the hippocampal gyrus, and it enters the lower and anterior extremity of the descending cornu of the lateral ventricle by passing through the choroidal fissure. In its course it gives twigs to the hippocampal gyrus and crus cerebri, and it terminates in the choroid plexus of the lateral ventricle.

Anterior Cerebral Artery.—This is the smaller of the two terminal branches of the internal carotid artery, and it has a more limited distribution than the other terminal branch, namely, the middle cerebral artery. It passes forwards and inwards, above the optic nerve, to the commencement of the great longitudinal fissure, where it is connected with its fellow of the opposite side by a short transverse vessel, called the **anterior communicating artery.** Thereafter it enters the great longitudinal fissure, along with its fellow, turns round the genu of the corpus callosum, and passes backwards over the upper surface of that body to the splenium, where it anastomoses with the posterior cerebral artery.

Branches.—These are arranged in two groups, antero-mesial or ganglionic and cortical.

The **antero-mesial** or **ganglionic branches,** small in size, pass through the lamina cinerea, along with twigs from the anterior communicating artery, and supply the front part of the caudate nucleus.

The **cortical branches** are as follows: (1) **internal orbital,** to the internal orbital gyrus, olfactory lobe, and gyrus rectus; (2) **anterior internal frontal,** to the superior frontal gyrus, the anterior two-thirds of the middle frontal gyrus, and the anterior part of the marginal gyrus; (3) **middle internal frontal,** to the callosal gyrus, the posterior part of the marginal gyrus, and the upper part of the precentral gyrus; and (4) **posterior internal frontal,** to the quadrate

lobule and the corpus callosum, the branch to the latter being known as the *artery of the corpus callosum.*

Anterior Communicating Artery.—This vessel connects the two anterior cerebral arteries at the entrance to the great longitudinal fissure, and lies over the lamina cinerea, in front of the optic commissure. It gives off a few twigs, which accompany the antero-mesial branches of each anterior cerebral artery.

Middle Cerebral Artery.—This is the larger of the two terminal branches of the internal carotid artery, and it has a wider distribution than the anterior cerebral artery. It enters the stem of the fissure of Sylvius, in which it passes outwards.

Branches.—These are arranged in two groups, antero-lateral or

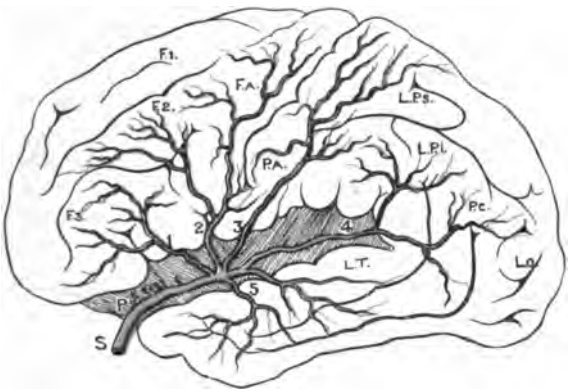


FIG. 585.—DISTRIBUTION OF THE LEFT MIDDLE CEREBRAL ARTERY (CHARCOT).

F.1. Superior Frontal Gyrus
F.2. Middle Frontal Gyrus
F.3. Inferior Frontal Gyrus
F.A. Ascending Frontal Gyrus
P.A. Ascending Parietal Gyrus
L.P.S. Superior Parietal Gyrus
L.P.I. Inferior Parietal Gyrus
P.C. Angular Gyrus
L.O. Occipital Lobe
L.T. Temporal Lobe
S. Middle Cerebral Artery entering Fissure of Sylvius
P. Lenticulo-striate Arteries
1. Artery to Broca's Gyrus (Inferior Frontal Gyrus)
2. Ascending Frontal Artery
3. Ascending Parietal Artery
4. Parieto-Temporal Artery
5. Arteries to Temporal Lobe

ganglionic and cortical. The **antero-lateral** or **ganglionic branches** pass through the locus perforatus anticus, and form two sets, internal striate and external striate. The **internal striate arteries** represent the lenticular arteries of Duret, and they supply the globus pallidus (inner part) of the lenticular nucleus, the internal capsule, and the caudate nucleus. The **external striate arteries** represent the lenticulo-striate and lenticulo-optic arteries of Duret. The **lenticulo-striate arteries** supply the putamen (outer part) of the lenticular nucleus and the external capsule. One of the lenticulo-striate arteries is larger than the others, and is subject to rupture in cases of cerebral hæmorrhage. It is known as the *artery of cere-*

bral hemorrhage (Charcot). Its course is outwards and upwards round the outer aspect of the lenticular nucleus, between it and the external capsule, and then through the internal capsule to the caudate nucleus. The **lenticulo-optic arteries** supply the posterior part of the lenticular nucleus and the anterior part of the optic thalamus on its outer aspect.

The **cortical branches** arise in the vicinity of the island of Reil, and are as follows : (1) **inferior external orbital,** to the orbital surface of the frontal lobe external to the internal orbital sulcus, and to the inferior frontal gyrus ; (2) **ascending frontal,** to the posterior

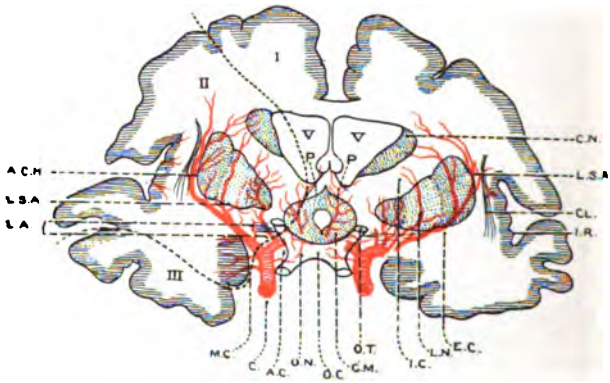


FIG. 586.—CORONAL SECTION OF THE CEREBRAL HEMISPHERES MADE ONE CENTIMETRE BEHIND THE OPTIC COMMISSURE (CHARCOT, FROM DURET).

(The Arteries of this region are shown).

I. Area of Anterior Cerebral Artery
II. Area of Middle Cerebral Artery
III. Area of Posterior Cerebral Artery
V.V. Sections of Anterior Cornua of Lateral Ventricles
P.P. Anterior Pillars of Fornix
C.N. Caudate Nucleus
L.S.A. Lenticulo-Striate Arteries
CL. Claustrum
I.R. Island of Reil
E.C. External Capsule
L.N. Lenticular Nucleus
I.C. Internal Capsule
O.T. Optic Tract (cut)
G.M. Grey Matter of Third Ventricle
O.C. Optic Commissure
O.N. Optic Nerve
A.C. Anterior Cerebral Artery
C. Internal Carotid Artery
M.C. Middle Cerebral Artery
L.A. Lenticular Arteries
A.C.H. Artery of Cerebral Hemorrhage

third of the middle frontal gyrus, and to the lower and greater part of the precentral gyrus ; (3) **ascending parietal,** to the postcentral gyrus and superior parietal gyrus ; (4) **parieto-temporal,** which traverses the posterior horizontal limb of the fissure of Sylvius, and supplies the inferior parietal gyrus, and the posterior parts of the superior and middle temporal gyri ; and (5) the **temporal branches,** which emerge from the posterior horizontal limb of the fissure of Sylvius, and supply the anterior and greater parts of the superior and middle temporal gyri.

Fourth or Intracranial Part of the Vertebral Artery.—The verte-

bral artery, on leaving the suboccipital triangle, pierces the dura mater and arachnoid, and enters the cranial cavity through the foramen magnum. As it ascends, it lies at first on the side of the medulla oblongata, between the hypoglossal nerve and the anterior root of the suboccipital nerve. It then passes upwards on the ventral surface of the medulla, and, on reaching the lower border of the pons Varolii, it unites with its fellow of the opposite side to form the basilar artery.

Branches.—These are as follows: posterior meningeal, posterior spinal, posterior inferior cerebellar, anterior spinal, and bulbar.

The **posterior meningeal artery** arises from the vertebral artery just before it pierces the dura mater, and it enters the cerebellar fossa of the occipital bone where it supplies the dura mater.

The **posterior spinal** artery arises from the vertebral artery immediately after it has pierced the dura mater. It descends upon the side of the spinal cord, in front of the posterior roots of the spinal nerves, and it gives off a branch which descends behind these roots. These two arteries, in themselves small, are reinforced by the spinal branches of the second part of the vertebral artery and of the dorsal branches of the intercostal arteries. In this manner lateral anastomotic arterial chains are formed upon each side of the spinal cord, in front of, and behind, the posterior nerve-roots.

The **posterior inferior cerebellar artery,** of large size, arises a little above the preceding branch. It passes backwards between the pneumogastric and spinal accessory nerves, and then over the restiform body to the vallecula of the cerebellum, where it divides into branches. Some of these supply the inferior vermis, and others ramify on the inferior surface of the cerebellar hemisphere, at the periphery of which they anastomose with branches of the superior cerebellar artery. The artery furnishes branches to the corresponding choroid plexus of the fourth ventricle and to the medulla oblongata.

The **anterior spinal branch** of the vertebral artery arises from that vessel near its termination. It passes obliquely downwards and inwards over the ventral aspect of the medulla oblongata, and at the median line it unites with its fellow of the opposite side to form the **anterior spinal artery** of the spinal cord. It furnishes twigs to the medulla oblongata.

The **bulbar branches** are distributed to the medulla oblongata.

Basilar Artery.—This vessel is formed by the union of the two vertebral arteries. It extends from the lower to the upper border of the pons Varolii, occupying the median basilar groove on its ventral surface. It lies beneath the arachnoid membrane, within the *cisterna pontis*, and at the upper border of the pons it divides into the two posterior cerebral arteries.

Branches.—These are as follows, on either side: transverse, internal auditory, anterior inferior cerebellar, superior cerebellar, and posterior cerebral.

The **transverse** or **pontine arteries** are numerous, and pass outwards on either side to supply the pons, the sensory and motor roots of the fifth cranial nerve, and the middle peduncle of the cerebellum.

The **internal auditory artery**, long and slender, accompanies the auditory nerve through the internal auditory meatus, and is distributed to the internal ear.

The **anterior inferior cerebellar artery** arises from the centre of the basilar, and passes backwards to be distributed to the anterior part of the inferior surface of the cerebellar hemisphere. It anastomoses with the posterior inferior cerebellar artery, which is a branch of the vertebral.

The **superior cerebellar artery** arises from the basilar close to its

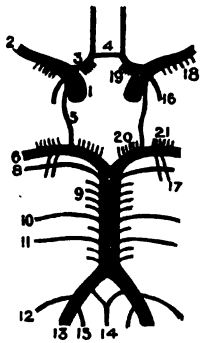


FIG. 587.—THE ARTERIES AT THE BASE OF THE BRAIN, AND THE CIRCLE OF WILLIS.

1. Internal Carotid
2. Middle Cerebral
3. Anterior Cerebral
4. Anterior Communicating
5. Posterior Communicating
6. Posterior Cerebral
7. Basilar
8. Superior Cerebellar
9. Transverse Pontine
10. Internal Auditory
11. Anterior Inferior Cerebellar
12. Posterior Inferior Cerebellar
13. Vertebral
14. Anterior Spinal
15. Posterior Spinal
16. Anterior Choroid
17. Posterior Choroid
18. Central or Ganglionic
19. Central or Ganglionic
20. Central or Ganglionic (Postero-mesial)
21. Central or Ganglionic (Postero-lateral)

termination. It passes outwards, parallel to the posterior cerebral artery, from which it is separated by the third cranial nerve. It then winds round the outer side of the crus cerebri, below the fourth cranial nerve, and so reaches the superior surface of the cerebellar hemisphere, where it divides into branches. These supply the superior vermis, the valve of Vieussens, the velum interpositum, and the superior surface of the cerebellar hemisphere, at the periphery of which they anastomose with branches of the inferior cerebellar arteries.

Posterior Cerebral Artery.—This is one of the terminal branches of the basilar artery, at the upper border of the pons Varolii. It passes at first outwards, beneath the crus cerebri, and parallel to the superior cerebellar artery, from which it is separated by the

third cranial nerve. It then winds round the outer side of the crus cerebri, lying between it and the hippocampal gyrus, and above the fourth cranial nerve. In this manner it reaches the tentorial or inferior and mesial surfaces of the occipital lobe of the cerebral hemisphere. It receives, not far from its commencement, the posterior communicating artery.

Branches.—These are arranged in two groups—ganglionic and cortical.

The **ganglionic group** includes three sets of branches, namely, postero-mesial, postero-lateral, and posterior choroidal.

The **postero-mesial ganglionic arteries** pass internal to the crus cerebri, and pierce the locus perforatus posticus. They supply the inner part of the crus cerebri and the posterior part of the optic thalamus.

The **postero-lateral ganglionic arteries** pass on the outer side of the crus cerebri, and supply the outer part of the crus, the posterior part of the optic thalamus, the corpora quadrigemina, and the corpora geniculata.

The **posterior choroidal arteries** are two or three in number, and pass through the choroidal fissure to the velum interpositum, which they supply, together with the choroid plexus of the lateral ventricle, and the corresponding choroid plexus of the third ventricle.

The **cortical branches** are as follows: (1) **anterior temporal,** to the anterior parts of the occipito-temporal and hippocampal gyri; (2) **posterior temporal,** to the posterior parts of the occipito-temporal and hippocampal gyri, and the inferior temporal gyrus; and (3) **occipital,** to the occipital lobe. One of the occipital branches is called the **calcarine artery.** It lies in the calcarine fissure, and supplies the lingual or infracalcarine gyrus and the cuneus.

Circle of Willis.—This circle is formed by (1) the anastomoses which take place between (*a*) the internal carotid and posterior cerebral arteries, through means of the posterior communicating arteries, and (*b*) the anterior cerebral arteries, through means of the anterior communicating artery; and (2) the connection between the two posterior cerebral arteries which is established by the basilar artery. It is situated at the base of the brain, and, though spoken of as a circle, it is really a heptagon—that is to say, it has seven sides and seven angles.

The circle is formed *in front* by the anterior communicating artery, which connects the two anterior cerebral arteries; *behind,* by the basilar artery, as it divides into the two posterior cerebral arteries; and *on either side* by (1) the anterior cerebral artery, (2) the trunk of the internal carotid artery, (3) the posterior communicating artery, and (4) the posterior cerebral artery, in this order from before backwards. The circle of Willis furnishes twigs to the grey cortex of the interpeduncular region. It serves to equalize the blood-pressure in the cerebral arteries, and it also provides for the regular supply of blood to the brain in cases where one of the main arterial trunks may be obstructed.

The following parts are contained within the circle of Willis, in order from behind forwards: (1) the locus perforatus posticus; (2) the corpora albicantia or mammillaria; (3) the tuber cinereum and infundibulum; and (4) the optic commissure or chiasma.

Veins of the Encephalon.

The **cerebral veins** are arranged in two groups—superficial and deep.

The **superficial cerebral veins** are divided into two sets—superior and inferior.

The **superior cerebral veins** return the blood from the upper parts of the outer surfaces of the cerebral hemispheres. They lie in the pia mater, and pierce the arachnoid membrane and inner layer of the dura mater, after which they open into the superior longitudinal sinus, having previously received the veins from the mesial surface of either hemisphere. Their direction, for the most part, is forwards and inwards, whilst the direction of the blood-current in the superior longitudinal sinus is backwards.

The **inferior cerebral veins** return the blood from the lower parts of the cerebral hemispheres, and they terminate in the cavernous, superior petrosal, and lateral sinuses. One of these veins is known as the **middle cerebral,** or **superficial Sylvian, vein.** It passes along the fissure of Sylvius, and opens into the front part of the cavernous sinus. This vein communicates posteriorly with (1) the superior longitudinal sinus, through means of the great or superior anastomotic vein; and (2) the lateral sinus, through means of the posterior anastomotic vein.

The **deep cerebral veins** are as follows: (1) the choroidal veins; (2) the veins of the corpora striata; (3) the veins of Galen; (4) the anterior cerebral veins; (5) the deep Sylvian veins; and (6) the basilar veins.

The **choroidal vein** of each side commences in the choroid plexus of the descending cornu of the lateral ventricle. It ascends at first, and then passes forwards in the lateral margin of the velum interpositum to the foramen of Monro, where it unites with the vein of the corpus striatum to form the corresponding vein of Galen.

The **vein of the corpus striatum** is formed by branches which issue from the corpus striatum and optic thalamus. It runs forwards in the groove between these two bodies, lying superficial to the tænia semicircularis, and at the foramen of Monro it joins the choroidal vein to form, as stated, the corresponding vein of Galen.

The **vein of Galen,** of each side, is formed close to the foramen of Monro by the union of the choroidal vein, and the vein of the corpus striatum. The two veins of Galen, right and left, pass backwards between the two layers of the velum interpositum, and they unite, beneath the splenium of the corpus callosum, to form one vessel, called the **vena magna Galeni,** which opens into the front part of the straight sinus. Each vein of Galen receives tributaries from

the optic thalamus, the corresponding choroid plexus of the third ventricle, the corpus callosum, and the corpora quadrigemina; and, prior to joining its fellow, it takes up the basilar vein of its own side. The **vena magna Galeni** receives tributaries from the upper surface of the cerebellum.

The **anterior cerebral vein** of each side is situated in the great longitudinal fissure, along with the corresponding artery. Having curved round the genu of the corpus callosum it passes to the region of the locus perforatus anticus, where it joins the deep Sylvian vein to form the basilar vein.

The **deep Sylvian vein** returns the blood from the island of Reil, and lies deeply within the stem of the fissure of Sylvius. At the locus perforatus anticus it joins the anterior cerebral vein to form, as stated, the basilar vein.

The **basilar vein** of each side commences at the locus perforatus anticus, where it is formed by the union of the anterior cerebral and deep Sylvian veins. It passes backwards round the crus cerebri, and opens into the vein of Galen of its own side, just before that vessel joins its fellow to form the vena magna Galeni. The basilar vein receives, close to its commencement, one or more inferior striate veins, which descend from the corpus striatum through the locus perforatus anticus. It also receives tributaries from the parts within the interpeduncular space.

The **cerebellar veins** are arranged in two groups—superior and inferior.

The **superior cerebellar veins** terminate in the vena magna Galeni, and in the straight, lateral, and superior petrosal sinuses. The **inferior cerebellar veins** pass to the lateral, inferior petrosal, and occipital sinuses.

Blood-supply of the Different Parts of the Encephalon.

The **medulla oblongata** is supplied by the vertebral, anterior spinal, and posterior inferior cerebellar arteries.

The **pons Varolii** is supplied by the transverse or pontine branches of the basilar artery.

The **cerebellum** is supplied *inferiorly* by the posterior inferior cerebellar branches of the vertebral arteries, and the anterior inferior cerebellar branches of the basilar artery. *Superiorly* it is supplied by the superior cerebellar branches of the basilar artery, and, to a limited extent, by the posterior inferior cerebellar arteries.

The **crus cerebri** is supplied by the postero-mesial and postero-lateral branches of the posterior cerebral artery, and by the posterior communicating artery.

The **locus perforatus posticus** is pierced by the postero-mesial branches of the posterior cerebral arteries.

The **corpora quadrigemina** are supplied by the postero-lateral branches of the posterior cerebral arteries.

The **optic thalamus** is supplied *posteriorly* by the postero-mesial and postero-lateral branches of the posterior cerebral artery. *Anteriorly* its outer part is supplied by the lenticulo-optic branches of the middle cerebral artery, and its inner part by the posterior communicating artery.

The **locus perforatus anticus** is pierced by the antero-lateral ganglionic branches of the middle cerebral artery.

Frontal Lobe.—The superior frontal gyrus, the anterior two-thirds of the middle frontal gyrus, and the upper portion of the precentral gyrus are supplied by cortical branches of the anterior cerebral artery. The posterior third of the middle frontal gyrus, the inferior frontal gyrus, and the lower and greater part of the precentral gyrus are supplied by cortical branches of the middle cerebral artery. On the orbital surface the internal orbital gyrus, olfactory lobe, and gyrus rectus are supplied by the anterior cerebral artery, whilst the remainder is supplied by the middle cerebral artery.

Parietal Lobe.—The whole of this lobe is supplied by the middle cerebral artery.

Occipital Lobe.—This lobe is supplied by the posterior cerebral artery.

Temporal Lobe.—The superior and middle temporal gyri are supplied by the middle cerebral artery, and the remainder is supplied by the posterior cerebral artery.

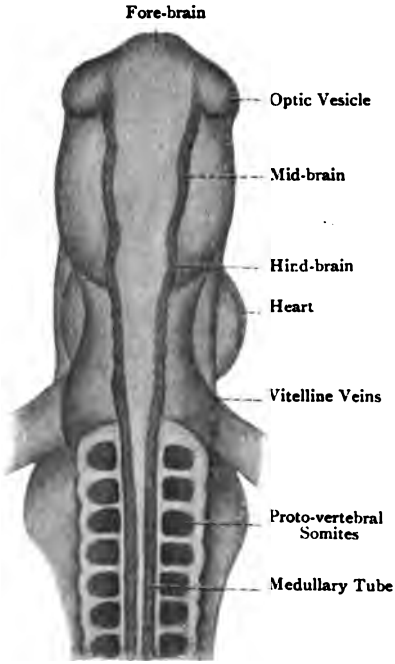


FIG. 588.—ANTERIOR PART OF AN EMBRYO CHICK AT THE END OF THE SECOND DAY (DORSAL VIEW) (KÖLLIKER).

Mesial Surface of the Cerebral Hemisphere.—The anterior cerebral artery has an extensive distribution to this surface, which it supplies as far back as the internal part of the parieto-occipital fissure. The parts behind this fissure, namely, the cuneus and the parts around the calcarine fissure, are supplied by the posterior cerebral artery.

The **corpus callosum** is supplied by the anterior cerebral arteries.

Corpus Striatum.—The **nucleus caudatus** and **nucleus lenticularis** are supplied, for the most part, by the antero-lateral or ganglionic branches of the middle cerebral artery, which pass through the locus perforatus anticus. According to Duret they form three sets—lenticular, lenticulo-striate, and lenticulo-optic. The **lenticular** (internal striate) **arteries** supply the globus pallidus (inner part) of the lenticular nucleus, the internal capsule, and the caudate nucleus. The **lenticulo-striate** (external striate) **arteries** supply the putamen (outer part) of the lenticular nucleus, and the external capsule. One of the lenticulo-striate arteries is larger than the others, and is subject to rupture in cases of cerebral hæmorrhage. It is known as the *artery of cerebral hemorrhage* (Charcot). Its course it outwards and upwards round the outer aspect of the lenticular nucleus, between it and the external capsule, and then through the internal capsule to the caudate nucleus. The **lenticulo-optic arteries** supply the posterior part of the lenticular nucleus, and the anterior part of the optic thalamus on its outer aspect.

The front part of the caudate nucleus is supplied by the antero-mesial branches of the anterior cerebral and anterior communicating arteries.

The larger arteries occupy the subarachnoid space, where they divide into branches which enter the pia mater. These in turn give off smaller branches, which enter the cerebral substance, some of them being cortical, and others medullary, in their distribution.

Blood-supply of the Choroid Plexuses.—The **choroid plexus of the lateral ventricle** derives its blood from (1) the anterior choroidal artery, which is a branch of the internal carotid ; and (2) the posterior choroidal arteries, which are branches of the posterior cerebral. The **choroid plexuses of the third ventricle** derive their blood from the posterior choroidal arteries. The **choroid plexuses of the fourth ventricle** derive their blood from the posterior inferior cerebellar arteries.

The **velum interpositum** derives its blood from the posterior choroidal arteries and from the superior cerebellar arteries.

Lymphatics of the Brain.—There are no lymphatic vessels in the brain. Their place is taken by spaces in the outer coat of the arteries, called **perivascular spaces**, which are in communication with the subarachnoid space.

Development of the Brain.

The brain is developed from the cephalic portion of the **neural tube.** This portion of the tube undergoes enlargement, and is divided by constrictions into the anterior, middle, and posterior primary cerebral vesicles. The *anterior cerebral vesicle* forms the **prosencephalon** or **fore-brain** ; the *middle cerebral vesicle* forms the **mesencephalon** or **mid-brain** ; and the *posterior cerebral vesicle* forms the **rhombencephalon** or **hind-brain.**

Subsequently the anterior and posterior primary cerebral vesicles become subdivided, each into two, thus giving rise to five vesicles, namely, first, second, third, fourth, and fifth, in this order from before backwards, these being known as the secondary cerebral vesicles.

The *first* vesicle forms the **telencephalon,** the *second* the **thalamencephalon** or **diencephalon,** the *third* the **mesencephalon,** the *fourth* the **metencephalon,** and the *fifth* the **myelencephalon.**

These formations will be made clear from the following table :

Anterior primary cerebral vesicle	= Prosencephalon, or fore-brain	= Telencephalon and Thalamencephalon or Diencephalon = First secondary vesicle; Second secondary vesicle
Middle primary cerebral vesicle	= Mesencephalon, or mid-brain	= Third secondary vesicle
Posterior primary cerebral vesicle	= Rhombencephalon, or hind-brain	= Metencephalon and Myelencephalon = Fourth secondary vesicle; Fifth secondary vesicle

The parts of the encephalon, formed from the foregoing subdivisions, are as follows :

Telencephalon.	**Thalamencephalon,** or **Diencephalon.**
Cerebral hemispheres.	Posterior part of third ventricle.
Lateral ventricles.	Optic thalami.
Anterior part of third ventricle.	Pineal body.
Foramina of Monro.	Interpeduncular structures.
Olfactory lobes.	Pituitary body.
	Optic nerve and retina.

Mesencephalon.	**Metencephalon.**	**Myelencephalon.**
Corpora quadrigemina.	Cerebellum.	Medulla oblongata or bulb.
Crura cerebri.	Pons Varolii.	Bulbar part of the fourth ventricle.
Aqueduct of Sylvius.	Pontine part of the fourth ventricle.	

The earliest change in the primitive brain takes the form of two hollow protrusions, called the **primary optic vesicles,** which grow outwards from the lateral parts of the anterior primary cerebral vesicle, one on either side. Each of these optic vesicles becomes enlarged at its terminal extremity, and the narrow portion, which connects it to the anterior cerebral vesicle, is known as the **optic stalk.** When the prosencephalon becomes divided into telencephalon and thalamencephalon or diencephalon, the optic vesicle is connected with the latter. It gives rise to the **optic nerve** and **retina.**

The next change in the primitive brain consists in the appearance of two other hollow protrusions, called the **vesicles of the cerebral hemispheres,** which grow forwards from the anterior primary cerebral vesicle, and subsequently upwards and backwards. The cavity of each **cerebral vesicle** gives rise to the corresponding **lateral ventricle.** The **corpus striatum,** of each side, is developed from the floor of the cerebral vesicle, and the **olfactory lobe** grows as a hollow protrusion from the antero-inferior part of the cerebral

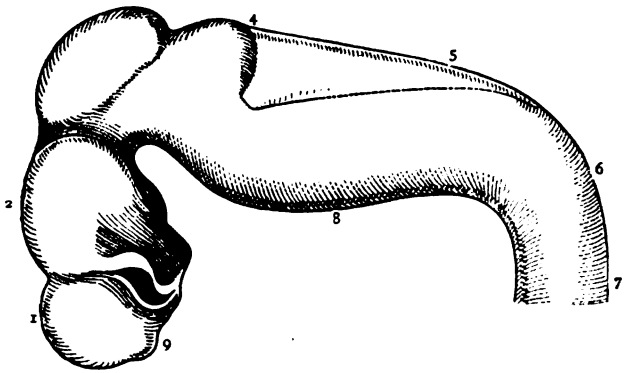


FIG. 589.—BRAIN OF AN EMBRYO ABOUT THREE AND A HALF WEEKS OLD. FROM QUAIN'S 'ANATOMY' (HIS).

1. Telencephalon
2. Thalamencephalon
3. Mesencephalon
4. Metencephalon
5. Myelencephalon
6. Cervical Flexure
7. Spinal Cord
8. Pontine Flexure
9. Olfactory Lobe

1, 2 = Prosencephalon; 3 = Mesencephalon; 4, 5 = Rhombencephalon

vesicle. This protrusion becomes solid, and gives rise to the **olfactory tract** and **olfactory bulb.**

The **choroidal fissure** is formed by an infolding of the mesial wall of the cerebral vesicle in the region of the foramen of Monro. Mesoblastic tissue gradually extends into the interval between the two layers of this fold—that is to say, into the choroidal fissure—and this tissue gives rise to the choroid plexus of the lateral ventricle.

The *anterior part* of the **third ventricle,** in the region of the foramina of Monro, is developed from the telencephalon; and the *posterior* and *greater part* represents the cavity of the thalamencephalon or diencephalon.

From the roof of the thalamencephalon a hollow protrusion grows upwards and forwards for a short distance in the median line, which gives rise to the **pineal body.** Another hollow protrusion grows downwards from the floor of the thalamencephalon. The lower part of this diverticulum becomes transformed into a reticulum of connective tissue, permeated by branched cells. This part forms the posterior lobe of the **pituitary body,** and the remainder of the diverticulum gives rise to the **infundibulum,** which remains

hollow in its upper part. The posterior and greater part of the third ventricle is developed from the cavity of the thalamencephalon. The **optic thalamus** of each side is developed in the lateral wall of the thalamencephalon.

The **corpora quadrigemina** are developed in the roof of the mesencephalon (middle primary cerebral vesicle); the **crura cerebri** are developed in its floor; and the **aqueduct of Sylvius** is a persistent part of its cavity.

The upper or pontine part of the fourth ventricle is developed from the cavity of the metencephalon (fourth secondary cerebral vesicle); the cerebellum is developed in its roof; and the pons Varolii is formed in its floor.

The lower or bulbar part of the fourth ventricle is developed from the cavity of the myelencephalon (fifth secondary cerebral vesicle), and the medulla oblongata or bulb is developed in its ventral wall.

The primitive brain, which is at first in line with the primitive spinal cord, subsequently undergoes several bends. The *first bend* is situated opposite the base of the middle primary cerebral vesical or mesencephalon, its concavity being ventrally placed. The effect of this bend is to direct the anterior primary cerebral vesicle or prosencephalon towards the ventral surface. The *second bend*, which is deep, is situated between mesencephalon and the posterior primary cerebral vesicle or rhombencephalon, its concavity being dorsally placed. The *third bend* is situated between the myelencephalon and the spinal cord. Its concavity is ventrally placed, and it causes the medulla oblongata to be gradually bent towards the ventral surface.

MENINGES OF THE ENCEPHALON.

Dura Mater.

The dura mater is a strong fibrous membrane which surrounds the encephalon, and is composed of two layers—outer and inner. The **outer** or **periosteal layer** serves as the internal periosteum or endocranium of the cranial bones, and the **inner** or **sustentacular layer** supports the encephalon. It is more firmly adherent to the bones forming the base of the skull than over the cranial vault, and it is also firmly attached along the course of the sutures. At the various openings it is prolonged outwards, blending with the sheaths of the transmitted nerves, and also becoming continuous with the external periosteum or pericranium. At the sphenoidal fissure it passes into the orbit to form the orbital periosteum. At the lower margin of the foramen magnum the two layers of which the dura mater is composed separate. The external layer blends with the periosteum of the occipital bone around the margin of the foramen magnum. The internal layer is prolonged into the spinal canal, and forms the theca of the spinal cord. The outer surface of the dura mater is rough and flocculent, owing to fibrous processes which connect it to the inner surfaces of the cranial bones. Its inner surface is smooth and covered by endothelium. Superiorly, on either side of the superior longitudinal sinus, there are several small granular nodules, called **Pacchionian bodies,** which are best marked in old age. They indent the parietal bone, and protrude into the superior longitudinal sinus, carrying with them prolongations from the endothelial lining of the sinus, which separate them from the blood.

The Pacchionian bodies are enlargements of the villi of the arachnoid membrane (see p. 1366).

Structure.—The dura mater consists of fibrous and elastic tissues, arranged as parallel bundles.

The intracranial dura mater differs from the dura mater of the spinal cord in the following respects : (1) it consists of two layers—outer or periosteal, and inner or sustentacular—whereas the spinal dura mater has only one layer, representing the sustentacular layer; (2) it furnishes certain processes or septa, which project into the cranial cavity, and separate parts of the encephalon from each other, whereas the spinal dura mater sends no septa into the spinal cord ; and (3) it contains venous sinuses, which are absent in the spinal dura mater.

Subdural Space.—This is the interval between the dura mater and the arachnoid membrane. There is really no space, but simply sufficient interval to contain a minute quantity of serous fluid for lubricating purposes. The dura mater and the arachnoid are therefore practically in contact with each other.

Blood-supply.—The cranial dura mater is supplied by the **meningeal arteries,** which are also distributed to the inner table and diploë of the cranial bones. These vessels are very numerous, and the chief are as follows on either side, from before backwards : (1) anterior meningeal, two in number, from the anterior and posterior ethmoidal arteries ; (2) meningeal, from the cavernous part of the internal carotid artery ; (3) small meningeal, from the middle meningeal, or from the first part of the internal maxillary artery ; (4) middle meningeal, from the first part of the internal maxillary ; (5) meningeal branches of the ascending pharyngeal artery ; (6) posterior meningeal branch of the occipital artery ; and (7) posterior meningeal, from the vertebral artery.

The **anterior meningeal branch of the anterior ethmoidal artery** arises from that vessel as it accompanies the nasal nerve on the cribriform plate of the ethmoid bone, and it takes part in the supply of the dura mater of the anterior fossa.

The **anterior meningeal branch of the posterior ethmoidal artery** arises from that vessel after it has entered the cranial cavity through a minute foramen between the cribriform plate of the ethmoid and the sphenoid. It has a limited distribution to the dura mater in this region.

The **meningeal branch of the internal carotid artery** arises from the cavernous part of that vessel, and enters the middle fossa to supply the dura mater.

The **small meningeal artery** is usually a branch of the middle meningeal, but it may arise from the first part of the internal maxillary artery. It enters the cranial cavity through the foramen ovale, and supplies the adjacent dura mater and the Gasserian ganglion.

The **middle meningeal artery,** as stated, is a branch of the first part of the internal maxillary artery. It is of large size, and enters the cranial cavity through the foramen spinosum in the sphenoid bone, after which it divides into two branches, anterior and posterior. The *anterior branch* passes forwards, outwards, and upwards in a groove on the upper surface of the great wing of the sphenoid bone to the inner aspect of the antero-inferior angle of the parietal bone, where there is a groove, or sometimes a short canal. The position of the middle meningeal artery at this level is ascertained by taking a point on the exterior of the skull 1½ inches behind the external angular process of the frontal bone, and 1½ inches above the zygomatic arch. From this point the artery ascends in a branching meningeal groove near the anterior border of the parietal bone, as high as the superior longitudinal sinus.

In this part of its course it furnishes numerous branches forwards and backwards.

The *posterior branch* passes outwards and upwards on the squamous part of the temporal bone, and then on to the inner aspect of the inferior border of the parietal bone, where there is a meningeal groove about the centre. From this point it ascends in a branching groove as high as the superior longitudinal sinus, giving off branches forwards and backwards.

The distribution of the middle meningeal artery extends as high as the superior longitudinal sinus, forwards on to the frontal bone, and backwards on to the occipital bone. Besides supplying the dura mater and the inner table and diploë of the bones, the vessel furnishes the following branches: (1) *Gasserian* to the Gasserian ganglion; (2) a *petrosal branch*, which passes through the hiatus Fallopii to supply the facial nerve in the aqueduct of Fallopius, and anastomose with the stylo-mastoid branch of the posterior

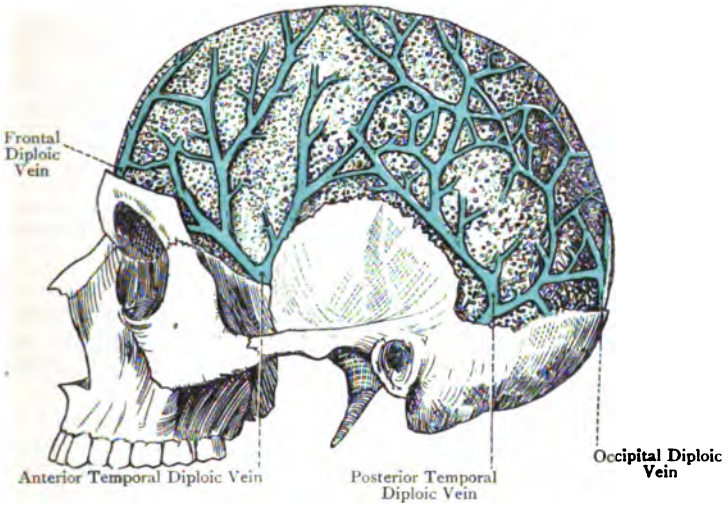


FIG. 590.—THE VEINS OF THE DIPLOË.

(The outer tables of the Cranial Bones have been removed).

auricular artery; and (3) an *orbital branch*, which enters the orbit through the sphenoidal fissure, and anastomoses with the ophthalmic artery.

The **meningeal branches of the ascending pharyngeal artery,** which is a branch of the external carotid, are three in number. One passes through the foramen lacerum medium into the middle fossa; another passes through the jugular foramen into the posterior fossa; and the third passes through the anterior condylar foramen, likewise into the posterior fossa.

The **posterior meningeal branch of the occipital artery** passes through the jugular foramen into the posterior fossa.

The **posterior meningeal branch of the vertebral artery** passes through the foramen magnum into the cerebellar fossa of the occipital bone.

Meningeal Veins.—The veins accompanying the middle meningeal artery are two in number. They pass through the foramen spinosum, and terminate in the pterygoid plexus of veins. The other meningeal veins are disposed in one of two ways. Some of them accompany the corresponding arteries and terminate in extracranial veins; whilst others terminate in the various intracranial venous sinuses, in part directly and in part through means of venous lacunæ.

Veins of the Diploë.—These vessels are situated in the cancellated tissue between the outer and inner plates of the cranial bones, and are exposed after removal of the outer plate. They are destitute of valves, and are arranged in the form of a network, from which the blood is returned by four diploic veins on either side, namely, frontal, anterior temporal, posterior temporal, and occipital. These terminate partly in extracranial veins, and partly in the intracranial venous sinuses and meningeal veins.

The **frontal diploic vein** passes downwards, and escapes through an opening in the outer plate of the frontal bone at the supra-orbital notch, where it joins the communicating vein which passes between the supra-orbital and ophthalmic veins. It receives radicles from the frontal air-sinus of the same side.

The **anterior temporal diploic vein** is confined to the back part of the frontal and anterior part of the parietal regions, and descends to terminate in two ways. It partly joins one of the extracranial deep temporal veins, by passing through an opening in the outer plate of the great wing of the sphenoid, and in part it ends in a meningeal vein, or in the spheno-parietal, or, it may be, the cavernous, sinus.

The **posterior temporal diploic vein** is confined to the parietal region, and descends to the postero-inferior angle of the parietal bone, where it pierces the inner plate of that bone, and terminates in the lateral sinus.

The **occipital diploic vein** occupies the occipital region, and pierces the inner table of the occipital bone, to terminate in the lateral sinus.

Nerves of the Dura Mater.—The dura mater receives nerves from (1) the sympathetic plexuses which accompany the arteries; (2) the three divisions of the fifth cranial nerve; (3) the ganglion of the root of the pneumogastric nerve; and (4) the hypoglossal nerve.

Processes of the Dura Mater.—The dura mater, as stated, is composed of two layers—outer or periosteal, and inner or sustentacular. The processes are formed by the inner or sustentacular layer, and are four in number, namely, the falx cerebri, tentorium cerebelli, falx cerebelli, and diaphragma sellæ.

The **falx cerebri** is an extensive falciform process, which occupies the great longitudinal fissure of the cerebrum, where it lies between the two cerebral hemispheres. *Anteriorly* it is almost pointed, and is attached to the *crista galli* of the ethmoid bone. *Posteriorly* it is broad, and is attached to the upper surface of the tentorium cerebelli along the median line, the straight sinus being situated at the place of junction. The *superior border* is convex, and is attached in the median line to the frontal, parietal, and occipital bones, extending upon the latter bone only as low as the internal occipital protuberance. The superior longitudinal sinus is situated along this border. The *inferior border* is concave and free. It overhangs the upper surface of the corpus callosum, from which it is separated by a slight interval. The inferior longitudinal sinus is situated within this border. The *lateral surfaces* face the mesial surfaces of the cerebral hemispheres.

The **tentorium cerebelli** is an extensive crescentic sheet which covers the cerebellum. *Superiorly* it supports the posterior parts of the cerebral hemispheres, and is elevated along the median line, whence it slopes towards the attached borders. *Anteriorly* it presents a free, sharp, concave border, which forms, with the dorsum sellæ of the sphenoid bone anteriorly, an oval opening, called the *incisura tentorii*, within which the mesencephalon is

placed. *Posteriorly* and *laterally* the tentorium cerebelli is convex, and is attached as follows, from behind forwards: (1) to the horizontal ridge on the inner surface of the tabular part of the occipital bone, where the process contains the lateral sinus; (2) to the inner aspect of the postero-inferior angle of the parietal bone, where the process also contains the lateral sinus; and (3) to the superior border of the petrous part of the temporal bone, where the process contains the superior petrosal sinus. Close to the apex of the *pars petrosa* the outer and anterior borders of the tentorium cerebelli cross, the outer border passing inwards to be attached to the posterior clinoid process of the sphenoid bone, and the anterior

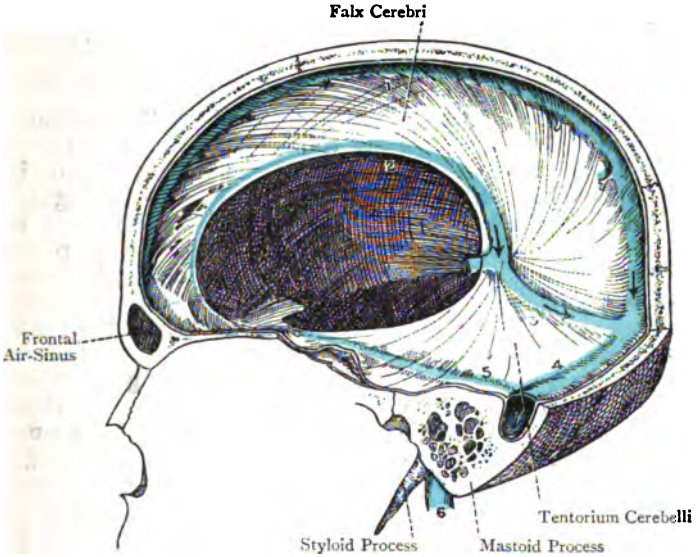


FIG. 591.—THE FALX CEREBRI, TENTORIUM CEREBELLI, AND VENOUS SINUSES OF THE DURA MATER (LEFT VIEW).

1. Superior Longitudinal Sinus
2. Inferior Longitudinal Sinus
3. Straight Sinus
4. Lateral Sinus
5. Superior Petrosal Sinus
6. Internal Jugular Vein

border passing forwards to be attached to the anterior clinoid process of that bone.

The **falx cerebelli** extends forwards into the posterior cerebellar notch, where it lies between the two cerebellar hemispheres. It is falciform in outline. *Superiorly* it is attached to the posterior part of the inferior surface of the tentorium cerebelli in the median line. *Posteriorly* it is attached to the internal occipital crest, and this portion bifurcates inferiorly, the two divisions being connected to the lateral margins of the vermiform fossa. Along this posterior

attachment it contains the occipital sinus and its two divisions. *Anteriorly* it ends in a free border.

The **diaphragma sellæ** is a small circular fold, horizontally placed, which forms a roof for the sella turcica or pituitary fossa of the sphenoid bone, and almost entirely covers the pituitary body. At its centre there is a small opening for the passage of the infundibulum.

Venous Sinuses of the Dura Mater.—These are blood-channels or spaces situated between the two layers of the dura mater, and lined with endothelium. They are as follows :

Superior longitudinal sinus.	Spheno-parietal sinuses (two).
Inferior longitudinal sinus.	Circular sinus.
Straight sinus.	Superior petrosal sinuses (two).
Lateral sinuses (two).	Inferior petrosal sinuses (two).
Occipital sinus.	Transverse or basilar sinus.
Cavernous sinuses (two).	Petro-squamous sinuses (two).

The superior longitudinal sinus is situated in the median line within the superior convex border of the falx cerebri. It extends from the *crista galli* of the ethmoid bone to the internal occipital protuberance, where, as a rule, it turns sharply to the right, and opens into the right lateral sinus. It sometimes, however, turns to the left, and opens into the left lateral sinus. Its posterior extremity is dilated, and forms the **torcular Herophili,** which usually occupies a depression on the right side of the internal occipital protuberance, and is connected with the dilatation at the posterior extremity of the straight sinus by a transverse vessel. It increases in size as it passes backwards, and its shape is triangular, the base being directed towards the cranial vault. The apex is directed downwards, and in this region the sinus is crossed by a number of delicate fibrous bands, called the **chordæ Willisii.** Opening into the sinus on either side there are venous spaces, called **lacunæ laterales,** which are situated within the dura mater, and projecting into these lacunæ from below, or into the sinus itself, there are several Pacchionian bodies, covered by the endothelial lining. The sinus receives the superior cerebral veins and some of the meningeal veins of the falx cerebri. The former open into it from *behind forwards*, so that the blood-flow in these veins is opposed to the current of blood in the sinus, which is from before backwards.

The superior longitudinal sinus frequently communicates anteriorly with the veins of the roof of the nose through the *foramen cæcum*, and it communicates with the veins of the scalp by means of an emissary vein, which passes through the parietal foramen of each side, when that is present.

The **inferior longitudinal sinus** (vein) is of small size, and is situated in the lower free border of the falx cerebri over its posterior two-thirds. Its direction is backwards, and it opens into the front part of the straight sinus at the anterior margin of the tentorium cerebelli. It is circular, and increases in size as it passes

backwards. Its tributaries are derived from the lower part of the falx cerebri, and from the adjacent parts of the mesial surfaces of the cerebral hemispheres.

The **straight sinus** is situated at the junction of the falx cerebri with the tentorium cerebelli, and is formed by the union between the inferior longitudinal sinus and the vena magna Galeni at the anterior margin of the tentorium. It is triangular, and increases in size from before backwards. Its course is downwards and backwards in the median line to the left side, as a rule, of the internal occipital protuberance, where it becomes slightly dilated, and is continued into the left lateral sinus. Its terminal dilatation is connected with the torcular Herophili by a transverse vessel. In those cases where the superior longitudinal sinus passes into the left lateral sinus, the straight sinus passes into the right lateral sinus. In addition to the inferior longitudinal sinus and the vena magna Galeni, the straight sinus receives some of the superior cerebellar veins and tributaries from the falx cerebri and tentorium cerebelli.

The **lateral sinuses** are two in number, right and left. Each sinus extends from the internal occipital protuberance to the postero-external compartment of the jugular foramen, through which it passes, to terminate in the bulb of the internal jugular vein. The sinus pursues a curved course. It passes outwards in the transverse groove on the inner surface of the tabular part of the occipital bone as far as the inner surface of the postero-inferior angle of the parietal bone. Here it ascends for a little in a groove, and, having described a sharp curve, it passes downwards and inwards in the sigmoid groove on the inner surface of the mastoid portion of the temporal bone. Finally, it turns forwards in the groove on the upper surface of the jugular process of the occipital bone to the jugular foramen. As far as the postero-inferior angle of the parietal bone the lateral sinus is contained within the attached border of the tentorium cerebelli, and, just before leaving this, it receives the superior petrosal sinus. The right lateral sinus is, as a rule, formed by the superior longitudinal sinus, and, in these circumstances, is larger than the left, which is usually formed by the straight sinus. The reverse, however, may be the case. As stated, the torcular Herophili and the terminal dilatation of the straight sinus are connected by a transverse branch.

The lateral sinus of each side, in addition to the superior petrosal sinus, receives tributaries from the posterior part of the cerebrum and the superior and inferior surfaces of the cerebellum. It also receives the posterior temporal and occipital diploic veins, and the petro-squamous sinus, when that sinus is present. Near its termination it communicates with the marginal sinus of the same side. The sinus communicates with extracranial veins by means of two large emissary veins, posterior condylar and mastoid, which pass through the corresponding foramina. These foramina,

however, being inconstant, the emissary veins referred to are sometimes awanting.

The **course of the lateral sinus** may be indicated, on the exterior, by drawing a line horizontally outwards from the external occipital protuberance to the base of the mastoid process, on a level with the auricular point, and then downwards in a curved manner to

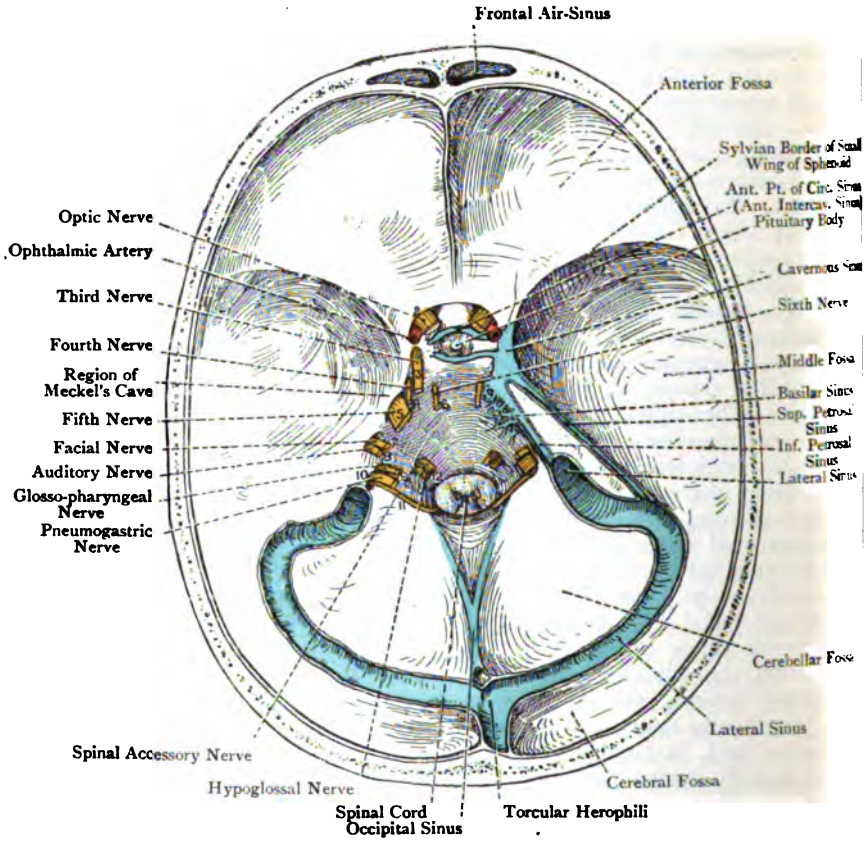


FIG. 592.—THE INTERNAL BASE OF THE SKULL, SHOWING THE CRANIAL NERVES AND VENOUS SINUSES.

the tip of the mastoid process. This latter part of the line is situated in the groove between the auricle and the mastoid process.

The **occipital sinus** is situated within the falx cerebelli along its attachment to the internal occipital crest. It is of small size, and is formed inferiorly by the union of the two *marginal sinuses* (inferior occipital) which lie on either side of the vermiform fossa and foramen

magnum, where they communicate with the posterior intraspinal veins and the terminal part of each lateral sinus. Superiorly it opens into the torcular Herophili. In certain cases the marginal or inferior occipital sinuses remain separate, and then each opens into the corresponding lateral sinus. The occipital sinus receives tributaries from the falx cerebelli and the inferior surface of the cerebellum, and it establishes a communication between the commencement and termination of the lateral sinuses.

The **cavernous sinuses** are two in number—right and left—and are so named because the interior of each is broken up by fibrous filaments, which impart to it a reticular appearance. Each sinus is situated on the side of the body of the sphenoid bone, and extends from the inner extremity of the sphenoidal fissure to the apex of the petrous part of the temporal bone. Anteriorly it receives the ophthalmic vein, or veins, from the orbit, and posteriorly it terminates by dividing into the superior and inferior petrosal sinuses. In addition to the ophthalmic vein, or veins, the cavernous sinus receives the spheno-parietal sinus and some of the inferior cerebral veins. It communicates with the angular vein of the face through the superior ophthalmic vein; with its fellow of the opposite side through the circular sinus; with the lateral sinus by the superior petrosal sinus; with the internal jugular vein by the inferior petrosal sinus; with the pterygoid plexus through the inferior ophthalmic vein, and by an emissary vein which passes through the foramen ovale, or through the foramen Vesalii; and with the pharyngeal plexus by an emissary vein which passes through the foramen lacerum medium. The internal carotid artery, with the cavernous sympathetic plexus, lies in contact with the inner wall of the sinus, and the sixth cranial nerve is close to the outer side of the artery. In connection with the outer wall of the sinus there are the third, fourth, and ophthalmic and superior maxillary divisions of the fifth, cranial nerves.

The **spheno-parietal sinuses** are two in number—right and left. Each is of small size, and is situated on the inferior surface of the small wing of the sphenoid bone. It generally commences in connection with the anterior temporal diploic vein, and terminates in the anterior part of the cavernous sinus.

The **circular sinus** surrounds the pituitary body in the pituitary fossa. It is composed of two transverse sinuses—anterior intercavernous and posterior intercavernous—which lie in front of and behind the pituitary body, and establish communications between the cavernous sinuses.

The **superior petrosal sinus** is situated along the superior border of the petrous part of the temporal bone, and lies within the attached margin of the tentorium cerebelli. It commences at the back part of the cavernous sinus, and, having passed outwards and backwards, it opens into the lateral sinus as that is about to enter the sigmoid groove of the *pars mastoidea*. It receives tributaries from the cerebellum and tympanum.

The **inferior petrosal sinus** occupies the groove at the junction of the basilar process of the occipital bone with the petrous part of the temporal bone. It commences at the back part of the cavernous sinus, and, passing backwards and slightly outwards, it leaves the cranial cavity through the antero-internal compartment of the jugular foramen, to terminate in the bulb of the internal jugular vein. It receives tributaries from the inferior surface of the cerebellum, and from the internal ear.

The **transverse** or **basilar sinus** is really a plexus of veins, situated within the dura mater over the basilar process of the occipital bone, and extending as low as the anterior margin of the foramen magnum, where it communicates with the anterior intraspinal veins. It connects the anterior ends of the inferior petrosal sinuses with each other.

The **petro-squamous sinuses** are two in number—right and left—and are situated, on either side, along the junction of the petrous and squamous parts of the temporal bone. The direction of each is backwards, and it opens into the lateral sinus as that is entering the sigmoid fossa of the *pars mastoidea*.

Each petro-squamous sinus represents the continuation of the lateral sinus, in early life, to terminate in the primitive jugular vein. Sometimes there are no traces of these petro-squamous sinuses.

Emissary Veins.—These are vessels which pass through foramina in the cranial wall, and serve to establish communications between the intracranial venous sinuses and the extracranial veins. The principal emissary veins are as follows: mastoid, nasal, posterior condylar, parietal, and occipital. In addition to these there are emissary veins, which pass through (1) the foramen ovale, (2) the foramen Vesalii (when present), and (3) the foramen lacerum medium.

The *lateral sinus*, in many cases, has two emissary veins, mastoid and posterior condylar.

The **mastoid emissary vein** is of large size. It passes through the mastoid foramen, and usually opens into the posterior jugular vein, but it may open into the posterior auricular vein.

The **posterior condylar emissary vein** passes through the posterior condylar foramen, and opens into the suboccipital plexus, from which the blood is carried away by the vertebral and deep cervical veins.

The mastoid and posterior condylar veins are not constant.

The *superior longitudinal sinus* has three emissary veins—nasal, parietal, and occipital.

The **nasal emissary vein** passes through the foramen cæcum, in front of the crista galli of the ethmoid bone, and it establishes a communication between the superior longitudinal sinus and the veins of the roof of the nose.

The **parietal emissary vein** passes through the parietal foramen, and opens into the occipital plexus, or into radicles of the superficial temporal vein.

The **occipital emissary vein** passes from the torcular Herophili to the occipital plexus, being transmitted through a minute foramen which pierces the external occipital protuberance.

The nasal, parietal, and occipital emissary veins are inconstant.

As previously stated, the **cavernous sinus** communicates with (1) the angular vein of the face, (2) the pterygoid plexus, and (3) the pharyngeal plexus. The **marginal** or **inferior occipital sinus** communicates with the posterior intraspinal veins, and the **transverse** or **basilar sinus** communicates with the anterior intraspinal veins.

Arachnoid Membrane.

This is a very delicate membrane which loosely surrounds the encephalon, and is situated between the dura mater and pia mater. It does not dip into the fissures, except in the case of the great longitudinal fissure, its general course being over the gyri and other eminences and depressions of the encephalon. It is conspicuous at the base of the encephalon in the region of the inter-peduncular space, pons Varolii, and medulla oblongata. Its outer surface is practically in close contact with the inner surface of the dura mater, the extremely slight interval containing a very little lubricating serous fluid, and being known as the **subdural space.** Between the arachnoid and the pia mater there is the interval known as the subarachnoid space. The membrane furnishes sheaths to the various cranial nerves.

Subarachnoid Space.—This space, as stated, is situated between the arachnoid and the pia mater. It is crossed by delicate trabeculæ of connective tissue, which pass between the two membranes in a reticular manner. The meshes of this reticulum contain the cerebro-spinal fluid.

The subarachnoid space communicates with the ventricles of the brain by means of five openings. Three of these communicate with the fourth ventricle, namely, the foramen of Magendie, and the foramina of Key and Retzius, the former being situated in the median line of the roof of the ventricle a little above the calamus scriptorius, and the latter being situated each in the roof of the lateral recess of the ventricle. The other two openings communicate with the descending cornua of the lateral ventricles, each being situated at the extremity of the corresponding cornu. In some situations—as, for example, over the gyri—the arachnoid and pia mater are in close contact; but in other localities the two membranes are more or less widely separated by intervals, called **cisternæ.** These are principally three in number, namely, the cisterna magna, cisterna pontis, and cisterna basalis.

The **cisterna magna** lies between the posterior part of the inferior surface of the cerebellum and the medulla oblongata. It is of large size, the arachnoid, which here passes from cerebellum to medulla, being widely separated from the pia mater. It is continuous through the foramen magnum with the posterior part of the subarachnoid space of the spinal cord.

The **cisterna pontis** is situated on the ventral aspect of the pons Varolii. Inferiorly it is continuous with the anterior part of the subarachnoid space of the spinal cord, and in the region of the medulla oblongata it is continuous posteriorly with the cisterna magna. It contains the basilar artery.

The **cisterna basalis** is situated in front of the pons Varolii, in which situation the arachnoid extends over the interpeduncular space from one temporal lobe to the other. It contains the arteries which form the circle of Willis. This cisterna is prolonged outwards

on each side into the stem of the fissure of Sylvius, each of these prolongations containing the middle cerebral artery. Anteriorly it extends in front of the optic commissure into the great longitudinal fissure over the upper surface of the corpus callosum, this prolongation containing the anterior cerebral arteries.

The **subarachnoid fluid** can be drained away in two directions. It can enter the lymph-spaces of the cranial nerves upon which the arachnoid is prolonged outwards in the form of sheaths; and it can enter the lacunæ laterales through the intervention of the Pacchionian bodies, and from these lacunæ it can make its way into the superior longitudinal sinus.

Structure of the Arachnoid Membrane.—The arachnoid consists of delicate bundles of fibrous tissue, which interlace with one another. Its external and internal surfaces are covered by endothelial cells.

The nerves of the arachnoid are derived from the sympathetic system.

Pacchionian Bodies.—These are small fleshy-looking bodies which are situated along the course of the superior longitudinal sinus, into which some of them project. They are also met with in connection with other sinuses, *e.g.*, the lateral and straight sinuses. Each Pacchionian body is a localized projection of the arachnoid membrane, with which it is connected by a narrow pedicle. As stated, some Pacchionian bodies project into the superior longitudinal sinus; others project from below into the lacunæ laterales. In all cases the bodies carry before them the lining of the sinus. Superficially the bodies give rise to the Pacchionian depressions on the internal surface of the parietal bone near the superior border. Each Pacchionian body, as stated, is a localized projection of the arachnoid membrane (enlarged villus—Luschka). It contains a prolongation of the subarachnoid space and reticulum. This is surrounded by a prolongation of the arachnoid membrane, and external to this is the endothelial lining of the sinus or of the lacuna. The Pacchionian bodies constitute channels through which the subarachnoid fluid can be drained away from the subarachnoid space into the lacunæ laterales, and thence into the superior longitudinal sinus, as well as into the other sinuses, *e.g.*, the lateral and straight sinuses. They are quite rudimentary in early life, and are most conspicuous in advanced life.

Pia Mater.

The pia mater is the most internal covering of the encephalon. It is a very vascular membrane, which invests, and is closely adherent to, the entire surface. From its internal surface delicate processes pass into the cerebral substance, which represent the minute bloodvessels, surrounded by pia-matral sheaths. The pia mater not only invests the external surface, but also dips into the sulci, and covers the opposed surfaces of the gyri. It also furnishes

sheaths to the various cranial nerves, which blend with their perineurium. It gives rise to two web-like expansions, namely, the tela choroidea inferior and tela choroidea superior.

The **tela choroidea inferior** is situated in the lower part of the roof of the fourth ventricle, and from it are derived the choroid plexuses of that ventricle. The **tela choroidea superior,** or *velum interpositum,* is an invagination of the pia mater through the transverse fissure beneath the splenium of the corpus callosum. It lies underneath the body of the fornix, and its deep surface is covered by the ependymal lining of the third ventricle, the latter forming the roof of that cavity. The tela choroidea superior furnishes the choroid plexuses of the two lateral and third ventricles.

The pia mater of the encephalon differs from the pia mater of the spinal cord in being thinner and less adherent to the nervous substance. The greater thinness is due to the fact that it is destitute of the outer layer which characterizes the spinal pia mater.

Structure.—The pia mater of the encephalon consists of a single layer of areolar tissue, which contains a great many small bloodvessels, these being derived from the larger vessels, lying in the subarachnoid space.

The Cranial Nerves.

The cranial nerves are arranged in twelve pairs. They have received numerical names according to the order in which they leave the cranial cavity from before backwards, and they are also known by functional names. The different pairs of nerves are as follows, in order from before backwards :

First, or **olfactory.**
Second, or **optic.**
Third, or **oculo-motor.**
Fourth, or **trochlear (pathetic).**
Fifth, or **trigeminal (trifacial).**
Sixth, or **abducent.**
Seventh, or **facial.**
Eighth, or **auditory.**
Ninth, or **glosso-pharyngeal.**
Tenth, or **pneumogastric (vagus).**
Eleventh, or **spinal accessory.**
Twelfth, or **hypoglossal.**

The cranial nerves are connected to certain parts of the encephalon. and these connections constitute their *superficial* or *apparent origins.* The fibres, however, can be traced to certain collections of grey matter, which are called **nuclei.** From the deep positions occupied by these nuclei they constitute the *deep origins* of the nerves.

First or Olfactory Nerve.—This nerve is a complex structure, and consists of (1) the olfactory lobe, and (2) the olfactory filaments or nerves, which are about twenty in number.

The **olfactory lobe** has been already described (see p. 1300).

The **olfactory nerves** are non-medullated. They arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa, and enter the cranial cavity through the foramina of one half of the cribriform plate of the ethmoid bone. Thereafter they enter the grey matter on the ventral or inferior aspect of the olfactory bulb, and terminate in arborizations which intermingle

with the arborizations formed by the dendrites of the mitral cells, situated in the granular layer of the bulb (see p. 1343).

The olfactory nerve is the nerve of smell.

Second or Optic Nerve.—This nerve arises from the brain by means of the optic tract, the deep connections of which have been already described (p. 1327). Each **optic tract** passes forwards and inwards to the **optic commissure** or **chiasma,** which is situated in

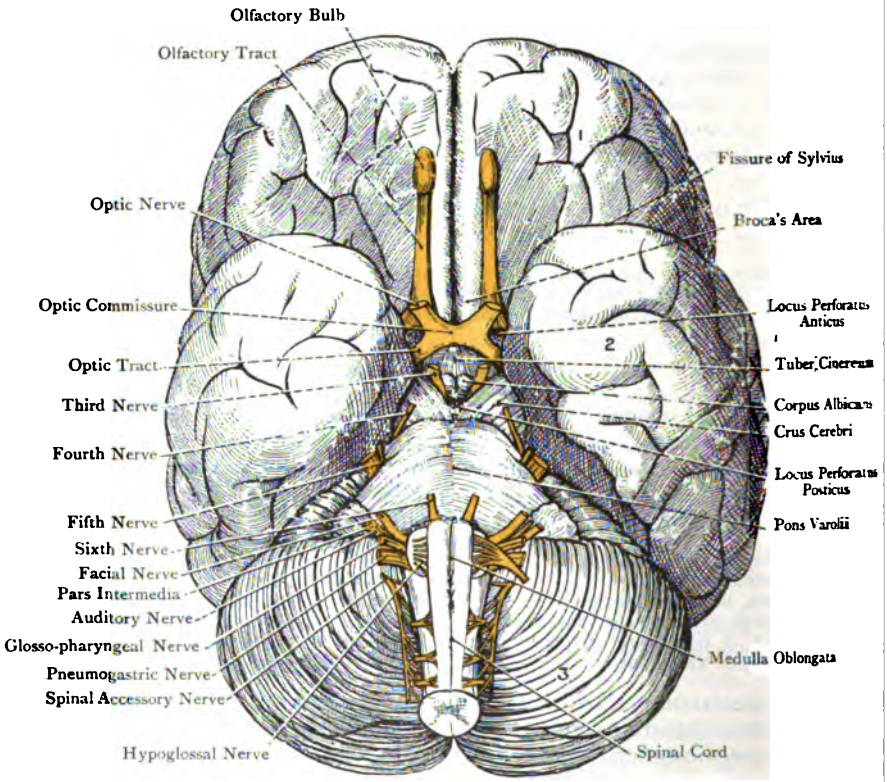


FIG. 593.—THE BASE OF THE ENCEPHALON, AND THE CRANIAL NERVES.

1, Frontal Lobe (Orbital Surface); 2, Temporal Lobe; 3, Cerebellum.

front of the interpeduncular space. The **optic nerve** of each side arises from the anterior part of the optic commissure. It courses forwards and outwards to the optic foramen, through which it passes into the orbit, piercing the dura mater, and receiving a sheath from it, as well as from the arachnoid membrane. Having reached the back part of the eyeball, it pierces the sclerotic and choroid coats $\frac{1}{8}$ inch to the nasal or inner side of the axis

of the eyeball, and terminates in an expansion which forms the most internal layer of the retina, called the nerve-fibre or optic layer.

The optic nerve is the nerve of sight.

Third or Oculo-motor Nerve.—The fibres of this nerve arise from the *oculo-motor nucleus*, which is situated in the grey matter of the ventral aspect (floor) of the aqueduct of Sylvius, on a level with

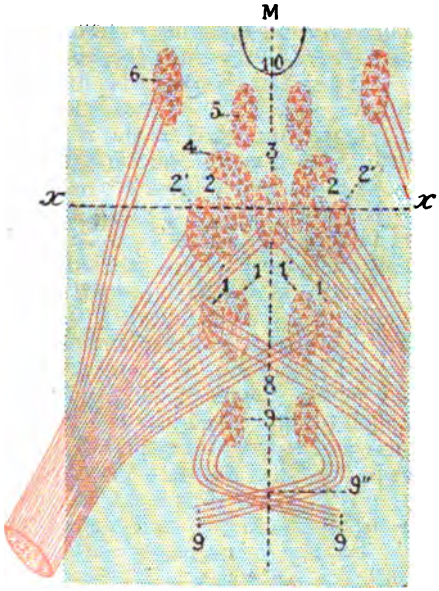


FIG. 594.—SCHEME SHOWING THE DIFFERENT CELL-GROUPS WHICH CONSTITUTE, ACCORDING TO PERLIA, THE NUCLEUS OF ORIGIN OF THE THIRD CRANIAL OR OCULO-MOTOR NERVE (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Posterior Dorsal Nucleus
1'. Posterior Ventral Nucleus
2. Anterior Dorsal Nucleus
2'. Anterior Ventral Nucleus
3. Central Nucleus
4. Nucleus of Edinger and Westphal
5. Antero-internal Nucleus
6. Antero-external Nucleus
7. Trunk of Oculo-Motor Nerve
8. Crossed Fibres
9. Fourth Cranial Nerve
9'. Nucleus of Origin of Fourth Nerve
9''. Intercrossing of Fourth Cranial Nerves
10. Third Ventricle

M. Middle Line

the upper quadrigeminal body, and extends superiorly, for a short distance, on to the lateral wall of the third ventricle. The nucleus is intimately related to the posterior longitudinal bundle, through means of which it is connected with the trochlear and abducent nuclei. All three nuclei receive collaterals from the posterior longitudinal bundle; and in this manner a functional association between these nuclei is maintained, and harmonious action is insured on the part of the muscles which are supplied by the nerves

attachment it contains the occipital sinus and its two divisions. *Anteriorly* it ends in a free border.

The **diaphragma sellæ** is a small circular fold, horizontally placed, which forms a roof for the sella turcica or pituitary fossa of the sphenoid bone, and almost entirely covers the pituitary body. At its centre there is a small opening for the passage of the infundibulum.

Venous Sinuses of the Dura Mater.—These are blood-channels or spaces situated between the two layers of the dura mater, and lined with endothelium. They are as follows :

Superior longitudinal sinus.	Spheno-parietal sinuses (two).
Inferior longitudinal sinus.	Circular sinus.
Straight sinus.	Superior petrosal sinuses (two).
Lateral sinuses (two).	Inferior petrosal sinuses (two).
Occipital sinus.	Transverse or basilar sinus.
Cavernous sinuses (two).	Petro-squamous sinuses (two).

The **superior longitudinal sinus** is situated in the median line within the superior convex border of the falx cerebri. It extends from the *crista galli* of the ethmoid bone to the internal occipital protuberance, where, as a rule, it turns sharply to the right, and opens into the right lateral sinus. It sometimes, however, turns to the left, and opens into the left lateral sinus. Its posterior extremity is dilated, and forms the **torcular Herophili,** which usually occupies a depression on the right side of the internal occipital protuberance, and is connected with the dilatation at the posterior extremity of the straight sinus by a transverse vessel. It increases in size as it passes backwards, and its shape is triangular, the base being directed towards the cranial vault. The apex is directed downwards, and in this region the sinus is crossed by a number of delicate fibrous bands, called the **chordæ Willisii.** Opening into the sinus on either side there are venous spaces, called **lacunæ laterales,** which are situated within the dura mater, and projecting into these lacunæ from below, or into the sinus itself, there are several Pacchionian bodies, covered by the endothelial lining. The sinus receives the superior cerebral veins and some of the meningeal veins of the falx cerebri. The former open into it from *behind forwards*, so that the blood-flow in these veins is opposed to the current of blood in the sinus, which is from before backwards.

The superior longitudinal sinus frequently communicates anteriorly with the veins of the roof of the nose through the *foramen cæcum*, and it communicates with the veins of the scalp by means of an emissary vein, which passes through the parietal foramen of each side, when that is present.

The **inferior longitudinal sinus** (vein) is of small size, and is situated in the lower free border of the falx cerebri over its posterior two-thirds. Its direction is backwards, and it opens into the front part of the straight sinus at the anterior margin of the tentorium cerebelli. It is circular, and increases in size as it passes

backwards. Its tributaries are derived from the lower part of the falx cerebri, and from the adjacent parts of the mesial surfaces of the cerebral hemispheres.

The **straight sinus** is situated at the junction of the falx cerebri with the tentorium cerebelli, and is formed by the union between the inferior longitudinal sinus and the vena magna Galeni at the anterior margin of the tentorium. It is triangular, and increases in size from before backwards. Its course is downwards and backwards in the median line to the left side, as a rule, of the internal occipital protuberance, where it becomes slightly dilated, and is continued into the left lateral sinus. Its terminal dilatation is connected with the torcular Herophili by a transverse vessel. In those cases where the superior longitudinal sinus passes into the left lateral sinus, the straight sinus passes into the right lateral sinus. In addition to the inferior longitudinal sinus and the vena magna Galeni, the straight sinus receives some of the superior cerebellar veins and tributaries from the falx cerebri and tentorium cerebelli.

The **lateral sinuses** are two in number, right and left. Each sinus extends from the internal occipital protuberance to the postero-external compartment of the jugular foramen, through which it passes, to terminate in the bulb of the internal jugular vein. The sinus pursues a curved course. It passes outwards in the transverse groove on the inner surface of the tabular part of the occipital bone as far as the inner surface of the postero-inferior angle of the parietal bone. Here it ascends for a little in a groove, and, having described a sharp curve, it passes downwards and inwards in the sigmoid groove on the inner surface of the mastoid portion of the temporal bone. Finally, it turns forwards in the groove on the upper surface of the jugular process of the occipital bone to the jugular foramen. As far as the postero-inferior angle of the parietal bone the lateral sinus is contained within the attached border of the tentorium cerebelli, and, just before leaving this, it receives the superior petrosal sinus. The right lateral sinus is, as a rule, formed by the superior longitudinal sinus, and, in these circumstances, is larger than the left, which is usually formed by the straight sinus. The reverse, however, may be the case. As stated, the torcular Herophili and the terminal dilatation of the straight sinus are connected by a transverse branch.

The lateral sinus of each side, in addition to the superior petrosal sinus, receives tributaries from the posterior part of the cerebrum and the superior and inferior surfaces of the cerebellum. It also receives the posterior temporal and occipital diploic veins, and the petro-squamous sinus, when that sinus is present. Near its termination it communicates with the marginal sinus of the same side. The sinus communicates with extracranial veins by means of two large emissary veins, posterior condylar and mastoid, which pass through the corresponding foramina. These foramina,

however, being inconstant, the emissary veins referred to are sometimes awanting.

The **course of the lateral sinus** may be indicated, on the exterior, by drawing a line horizontally outwards from the external occipital protuberance to the base of the mastoid process, on a level with the auricular point, and then downwards in a curved manner to

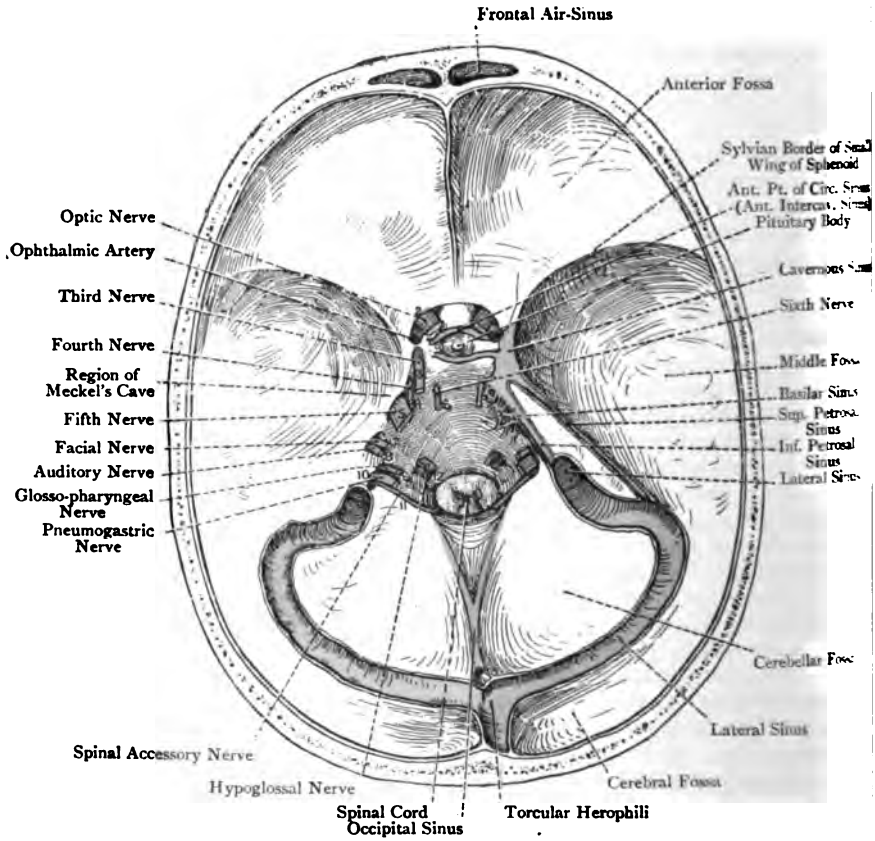


FIG. 592.—THE INTERNAL BASE OF THE SKULL, SHOWING THE CRANIAL NERVES AND VENOUS SINUSES.

the tip of the mastoid process. This latter part of the line is situated in the groove between the auricle and the mastoid process.

The **occipital sinus** is situated within the falx cerebelli along its attachment to the internal occipital crest. It is of small size, and is formed inferiorly by the union of the two ***marginal sinuses*** (inferior occipital) which lie on either side of the vermiform fossa and foramen

magnum, where they communicate with the posterior intraspinal veins and the terminal part of each lateral sinus. Superiorly it opens into the torcular Herophili. In certain cases the marginal or inferior occipital sinuses remain separate, and then each opens into the corresponding lateral sinus. The occipital sinus receives tributaries from the falx cerebelli and the inferior surface of the cerebellum, and it establishes a communication between the commencement and termination of the lateral sinuses.

The **cavernous sinuses** are two in number—right and left—and are so named because the interior of each is broken up by fibrous filaments, which impart to it a reticular appearance. Each sinus is situated on the side of the body of the sphenoid bone, and extends from the inner extremity of the sphenoidal fissure to the apex of the petrous part of the temporal bone. Anteriorly it receives the ophthalmic vein, or veins, from the orbit, and posteriorly it terminates by dividing into the superior and inferior petrosal sinuses. In addition to the ophthalmic vein, or veins, the cavernous sinus receives the spheno-parietal sinus and some of the inferior cerebral veins. It communicates with the angular vein of the face through the superior ophthalmic vein; with its fellow of the opposite side through the circular sinus; with the lateral sinus by the superior petrosal sinus; with the internal jugular vein by the inferior petrosal sinus; with the pterygoid plexus through the inferior ophthalmic vein, and by an emissary vein which passes through the foramen ovale, or through the foramen Vesalii; and with the pharyngeal plexus by an emissary vein which passes through the foramen lacerum medium. The internal carotid artery, with the cavernous sympathetic plexus, lies in contact with the inner wall of the sinus, and the sixth cranial nerve is close to the outer side of the artery. In connection with the outer wall of the sinus there are the third, fourth, and ophthalmic and superior maxillary divisions of the fifth, cranial nerves.

The **spheno-parietal sinuses** are two in number—right and left. Each is of small size, and is situated on the inferior surface of the small wing of the sphenoid bone. It generally commences in connection with the anterior temporal diploic vein, and terminates in the anterior part of the cavernous sinus.

The **circular sinus** surrounds the pituitary body in the pituitary fossa. It is composed of two transverse sinuses—anterior intercavernous and posterior intercavernous—which lie in front of and behind the pituitary body, and establish communications between the cavernous sinuses.

The **superior petrosal sinus** is situated along the superior border of the petrous part of the temporal bone, and lies within the attached margin of the tentorium cerebelli. It commences at the back part of the cavernous sinus, and, having passed outwards and backwards, it opens into the lateral sinus as that is about to enter the sigmoid groove of the *pars mastoidea*. It receives tributaries from the cerebellum and tympanum.

The **inferior petrosal sinus** occupies the groove at the junction of the basilar process of the occipital bone with the petrous part of the temporal bone. It commences at the back part of the cavernous sinus, and, passing backwards and slightly outwards, it leaves the cranial cavity through the antero-internal compartment of the jugular foramen, to terminate in the bulb of the internal jugular vein. It receives tributaries from the inferior surface of the cerebellum, and from the internal ear.

The **transverse** or **basilar sinus** is really a plexus of veins, situated within the dura mater over the basilar process of the occipital bone, and extending as low as the anterior margin of the foramen magnum, where it communicates with the anterior intraspinal veins. It connects the anterior ends of the inferior petrosal sinuses with each other.

The **petro-squamous sinuses** are two in number—right and left—and are situated, on either side, along the junction of the petrous and squamous parts of the temporal bone. The direction of each is backwards, and it opens into the lateral sinus as that is entering the sigmoid fossa of the *pars mastoidea*.

Each petro-squamous sinus represents the continuation of the lateral sinus, in early life, to terminate in the primitive jugular vein. Sometimes there are no traces of these petro-squamous sinuses.

Emissary Veins.—These are vessels which pass through foramina in the cranial wall, and serve to establish communications between the intracranial venous sinuses and the extracranial veins. The principal emissary veins are as follows: mastoid, nasal, posterior condylar, parietal, and occipital. In addition to these there are emissary veins, which pass through (1) the foramen ovale, (2) the foramen Vesalii (when present), and (3) the foramen lacerum medium.

The *lateral sinus*, in many cases, has two emissary veins, mastoid and posterior condylar.

The **mastoid emissary vein** is of large size. It passes through the mastoid foramen, and usually opens into the posterior jugular vein, but it may open into the posterior auricular vein.

The **posterior condylar emissary vein** passes through the posterior condylar foramen, and opens into the suboccipital plexus, from which the blood is carried away by the vertebral and deep cervical veins.

The mastoid and posterior condylar veins are not constant.

The *superior longitudinal sinus* has three emissary veins—nasal, parietal, and occipital.

The **nasal emissary vein** passes through the foramen cæcum, in front of the crista galli of the ethmoid bone, and it establishes a communication between the superior longitudinal sinus and the veins of the roof of the nose.

The **parietal emissary vein** passes through the parietal foramen, and opens into the occipital plexus, or into radicles of the superficial temporal vein.

The **occipital emissary vein** passes from the torcular Herophili to the occipital plexus, being transmitted through a minute foramen which pierces the external occipital protuberance.

The nasal, parietal, and occipital emissary veins are inconstant.

As previously stated, the **cavernous sinus** communicates with (1) the angular vein of the face, (2) the pterygoid plexus, and (3) the pharyngeal plexus. The **marginal** or **inferior occipital sinus** communicates with the posterior intraspinal veins, and the **transverse** or **basilar sinus** communicates with the anterior intraspinal veins.

Arachnoid Membrane.

This is a very delicate membrane which loosely surrounds the encephalon, and is situated between the dura mater and pia mater. It does not dip into the fissures, except in the case of the great longitudinal fissure, its general course being over the gyri and other eminences and depressions of the encephalon. It is conspicuous at the base of the encephalon in the region of the inter-peduncular space, pons Varolii, and medulla oblongata. Its outer surface is practically in close contact with the inner surface of the dura mater, the extremely slight interval containing a very little lubricating serous fluid, and being known as the **subdural space.** Between the arachnoid and the pia mater there is the interval known as the subarachnoid space. The membrane furnishes sheaths to the various cranial nerves.

Subarachnoid Space.—This space, as stated, is situated between the arachnoid and the pia mater. It is crossed by delicate trabeculæ of connective tissue, which pass between the two membranes in a reticular manner. The meshes of this reticulum contain the cerebro-spinal fluid.

The subarachnoid space communicates with the ventricles of the brain by means of five openings. Three of these communicate with the fourth ventricle, namely, the foramen of Magendie, and the foramina of Key and Retzius, the former being situated in the median line of the roof of the ventricle a little above the calamus scriptorius, and the latter being situated each in the roof of the lateral recess of the ventricle. The other two openings communicate with the descending cornua of the lateral ventricles, each being situated at the extremity of the corresponding cornu. In some situations—as, for example, over the gyri—the arachnoid and pia mater are in close contact; but in other localities the two membranes are more or less widely separated by intervals, called **cisternæ.** These are principally three in number, namely, the cisterna magna, cisterna pontis, and cisterna basalis.

The **cisterna magna** lies between the posterior part of the inferior surface of the cerebellum and the medulla oblongata. It is of large size, the arachnoid, which here passes from cerebellum to medulla, being widely separated from the pia mater. It is continuous through the foramen magnum with the posterior part of the subarachnoid space of the spinal cord.

The **cisterna pontis** is situated on the ventral aspect of the pons Varolii. Inferiorly it is continuous with the anterior part of the subarachnoid space of the spinal cord, and in the region of the medulla oblongata it is continuous posteriorly with the cisterna magna. It contains the basilar artery.

The **cisterna basalis** is situated in front of the pons Varolii, in which situation the arachnoid extends over the interpeduncular space from one temporal lobe to the other. It contains the arteries which form the circle of Willis. This cisterna is prolonged outwards

(2) the internal nucleus, or nucleus of the descending root; and (3) the external nucleus, or nucleus of Deiters.

The *dorsal* or *principal nucleus* is situated in the floor of the fourth ventricle, underneath the acustic area, and therefore belongs to both the pontine and bulbar portions of the floor. The striæ acusticæ cross it superficially. The *internal nucleus*, or *nucleus of the descending root*, is situated in the bulbar part of the floor, and receives those fibres of the vestibular root which descend through the lower part of the pons into the medulla. The *external nucleus*, or *nucleus of Deiters*, is associated with the descending root. Superiorly it is situated in the lateral wall of the fourth ventricle, and its upper and outer part is known as the *nucleus of Bechterew*. The external nucleus receives a great many of the fibres of the vestibular root.

The cochlear and vestibular roots have certain central connections, which will now be briefly stated.

Cochlear Root.—This is the nerve of hearing. As stated, its fibres terminate in connection with the ventral cochlear nucleus and the lateral cochlear nucleus (tuberculum acusticum). The axons of the cells of the ventral cochlear nucleus give rise to the corpus trapezoides, and the axons of the cells of the lateral cochlear nucleus give rise to the striæ acusticæ. The fibres of the corpus trapezoides cross to the opposite side, after which they ascend as the **lateral fillet.** In this course the fibres are interrupted by three groups of cells, namely, (1) those of the superior olive of their own side; (2) those of the superior olive of the side to which they cross; and (3) those of the nucleus of the lateral fillet. The lateral fillet ultimately terminates in the lower quadrigeminal body and corpus geniculatum internum of its own side.

The *striæ acusticæ* arise as the axons of the cells of the lateral cochlear nucleus. They wind round the posterior aspect of the restiform body, and then cross the floor of the fourth ventricle. On reaching the median line they sink into the adjacent portions of the medulla and pons, and then cross to the opposite side, where they become part of the lateral fillet of that side. The lateral fillet is therefore composed of: (1) the fibres of the corpus trapezoides, and (2) the striæ acusticæ, both of the opposite side, and it serves to connect the ventral and lateral cochlear nuclei with the lower quadrigeminal body and corpus geniculatum internum of the opposite side. The two cochlear nuclei are also to a certain extent connected with the lower quadrigeminal body of their own side, but not with the corpus geniculatum internum of their own side. Finally, the corpus geniculatum internum is connected with the cortex of the superior temporal gyrus.

The cochlear root is connected with the oculo-motor, trochlear, and abducent nuclei by fibres which pass to these nuclei from the superior olive.

Vestibular Root.—This is the nerve of equilibrium. The dorsal nucleus and external nucleus, or nucleus of Deiters, are connected with the *superior vermis* of the cerebellum by means of the direct

sensory cerebellar tract (Edinger), the fibres of which, for the most part, come from the cerebellar hemisphere of the opposite side.

The auditory nerve makes its superficial appearance at the lower border of the pons Varolii in front of the restiform body, where it lies on the outer side of the facial nerve, the pars intermedia of Wrisberg intervening between the two.

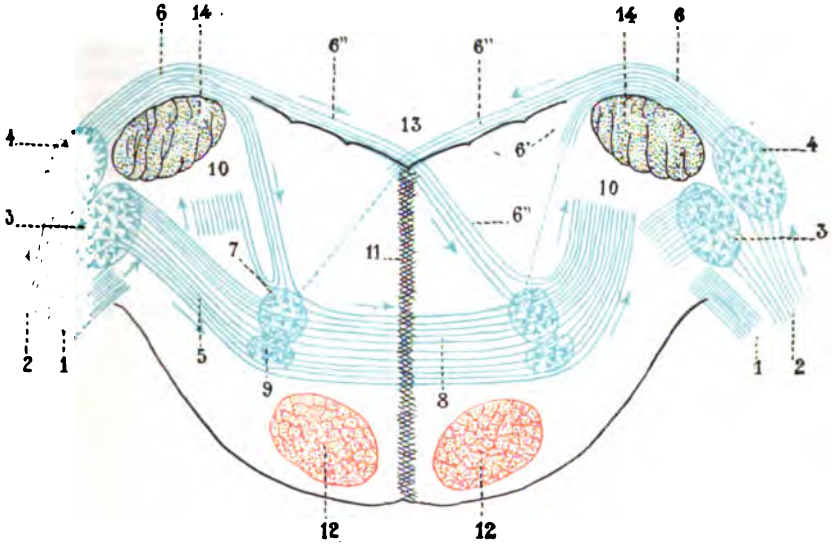


FIG. 596.—TERMINAL NUCLEI OF THE COCHLEAR NERVE, WITH THEIR SUPERIOR CONNECTIONS (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

(The vestibular root and its terminal nuclei, with the efferent fibres of these latter, have been suppressed. In order not to obscure the trapezoid body, the efferent fibres of the terminal nuclei of the right side have been in a great part of their extent resected. The trapezoid body is consequently composed of only half of its fibres—namely, those which come from the left).

1. Vestibular Root of Auditory Nerve
2. Cochlear Root
3. Accessory Nucleus of Auditory Nerve
4. Lateral Nucleus, or Tuberculum Acusticum
5. Efferent Fibres of Accessory Nucleus
6. Efferent Fibres of Lateral Nucleus, forming the Striæ Acusticæ
6'. Direct Fibres of the Striæ Acusticæ going to the Superior Olivary Body of the same side
6". Crossed Fibres of the Striæ Acusticæ going to the Superior Olivary Body of the opposite side
7. Superior Olivary Body
8. Corpus Trapezoides
9. Trapezoid Nucleus
10. Lateral Fillet
11. Raphé
12. Pyramidal Tract
13. Fourth Ventricle
14. Inferior Peduncle of Cerebellum (Restiform Body)

Ninth or Glosso-pharyngeal Nerve.—This nerve consists of afferent and efferent fibres. The **afferent fibres** (sensory) arise from the cells of the *jugular and petrous ganglia*, which resemble those of the Gasserian and spinal ganglia. Having entered the medulla oblongata, they terminate in two ways. (1) Some of them

end in arborizations around the cells of the *vagal nucleus*, which lies underneath the **trigonum vagi** in the lower part of the floor of the fourth ventricle. (2) Other fibres enter the strand, called the **fasciculus solitarius**, in which they descend to terminate in connection with the cells of the surrounding grey matter. The **efferent fibres** (motor) arise from the cells of the *accessory vagal nucleus*, or *nucleus ambiguus*.

The fasciculi of the glosso-pharyngeal nerve make their superficial appearance in the postero-lateral sulcus of the medulla oblongata, between the olivary and restiform bodies, immediately below the facial nerve.

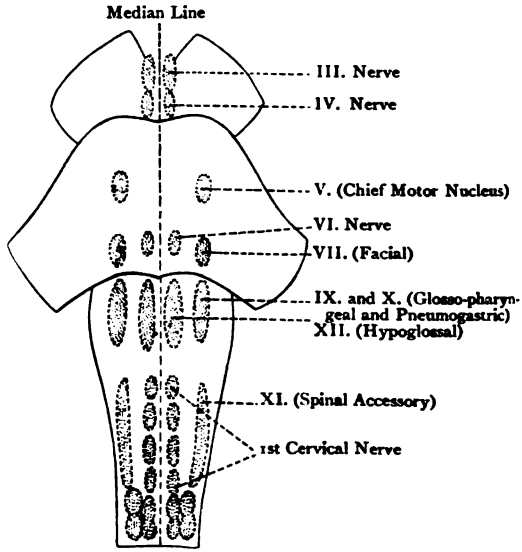


FIG. 597.—SCHEME SHOWING THE CONTINUATION OF THE GREY MATTER OF THE SPINAL CORD INTO THE MEDULLA OBLONGATA, PONS VAROLII, AND CRURA CEREBRI (POIRIER).

(The separation into two columns on either side and the breaking up of these into Cranial Motor Nuclei are indicated).

The glosso-pharyngeal nerve is distributed to the tongue and pharynx, as well as to the stylo-pharyngeus muscle.

Tenth, Pneumogastric, or Vagus Nerve.—This nerve consists of afferent and efferent fibres. The **afferent fibres** (sensory) arise from the cells of the *ganglion of the root* and *the ganglion of the trunk*, which resemble those of the Gasserian and spinal ganglia. Having entered the medulla oblongata, they terminate in two ways. (1) Some of them end in arborizations around the cells of the vagal nucleus, which, as stated, lies underneath the **trigonum**

vagi in the lower part of the floor of the fourth ventricle. (2) Other fibres enter the strand, called the **fasciculus solitarius,** in which they descend to terminate in connection with the cells of the surrounding grey matter. The **efferent fibres** (motor) arise from the cells of the *accessory vagal nucleus*, or *nucleus ambiguus*.

The fasciculi of the pneumogastric nerve make their superficial appearance in the postero-lateral sulcus of the medulla oblongata, in front of the restiform body, and below the fasciculi of the glosso-pharyngeal nerve.

The pneumogastric nerve is distributed to the pharynx, œsophagus, and stomach, and to the organs of respiration, this distribution being sensory.

In connection with the deep origins of the glosso-pharyngeal and pneumogastric nerves, the following structures fall to be described, namely, (1) the vagal nucleus, (2) the nucleus ambiguus, and (3) the fasciculus solitarius. The **vagal nucleus** is intimately related to the hypoglossal nucleus, and, like it, lies partly in the *open part* and partly in the *closed part* of the medulla oblongata. In the open part it lies underneath the **trigonum vagi,** external to the hypoglossal nucleus, and extends as high as the striæ acusticæ. In the closed part of the medulla it descends very nearly as low as a point just above the decussation of the pryamids, and here it lies behind the hypoglossal nucleus.

According to some authorities, the vagal nucleus is a nucleus of *termination*, receiving afferent or sensory fibres from the glosso-pharyngeal and pneumogastric nerves, which terminate in arborizations around its cells. According to other authorities, it is a nucleus of *origin*, furnishing efferent or motor fibres to these two nerves.

The **nucleus ambiguus,** or **accessory vagal nucleus,** is usually regarded as the source of the efferent or motor-fibres of the glosso-pharyngeal and pneumogastric nerves. Its cells are continuous with the anterior cornual cells of the spinal cord, and are arranged in the form of a strand, which lies in the *formatio reticularis grisea* of the medulla oblongata.

The **fasciculus solitarius** is composed of longitudinal fibres, which represent the afferent fibres of the glosso-pharyngeal and pneumogastric nerves. It occupies a deeper position than the vagal nucleus, and extends throughout the entire length of the medulla oblongata. The fasciculus is surrounded by grey matter, containing small nerve-cells, in connection with which its constituent fibres terminate.

Eleventh or Spinal Accessory Nerve.—This nerve consists of two portions—spinal and accessory or bulbar.

The **spinal portion** arises by several roots from cells in the anterior grey cornu of the spinal cord, which are situated posterior to the lateral group of anterior cornual cells, and extend as low as the fifth cervical nerve. The roots emerge at intervals from the lateral column of the cord, and join to form the spinal portion, which ascends to the foramen magnum, lying between the ligamentum

denticulatum and the posterior roots of the adjacent spinal nerves.

The **accessory** or **bulbar portion** arises in the medulla oblongata or bulb from cells which are associated with the nucleus ambiguus. The fasciculi of the spinal accessory nerve make their appearance on the medulla oblongata below the fasciculi of the pneumogastric nerve, and they continue to emerge from the lateral column of the spinal cord as low as the level of the fifth cervical nerve.

The **spinal portion** of the spinal accessory nerve is distributed to the trapezius and sterno-cleido-mastoid muscles. The **accessory** or **bulbar portion** (*motor*), through the pneumogastric to which it is accessory, is distributed to (1) the muscles of the soft palate; (2) the constrictor muscles of the pharynx; (3) the muscular fibres of the œsophagus, stomach, and intestinal canal; (4) the muscular tissue of the organs of respiration; and (5) the muscular tissue of the heart, the fibres to the cardiac muscular tissue being *inhibitory*.

Twelfth or Hypoglossal Nerve.—The fibres of this nerve arise from the *hypoglossal nucleus*, which is situated in the medulla oblongata. The upper part of this nucleus extends as high as the striæ acusticæ. and corresponds to the area on the lower half of the floor of the fourth ventricle, which is called the **trigonum hypoglossi.** The lower part of the nucleus is contained within the closed part of the medulla, and extends as low as a point above the decussation of the pyramids. The nerve-fasciculi pass through the medulla in a dorso-ventral direction, lying between its anterior and lateral areæ, and between the formatio reticularis alba and formatio reticularis grisea.

The fasciculi of the hypoglossal nerve make their superficial appearance in the antero-lateral sulcus of the medulla oblongata between the pyramid and the olivary body.

The hypoglossal nerve is distributed to the muscles of the tongue.

Cranio-cerebral Topography.

The **bregma,** or point of junction of the sagittal and coronal sutures, corresponds to the centre of a line connecting the two auricular points (the centre of the orifice of the meatus auditorius externus).

The **lambda,** or meeting of the sagittal and lambdoidal sutures, is situated about 2¾ inches above the inion, or external occipital protuberance.

The **pterion,** or region of the spheno-parietal suture, is situated about 1½ inches behind the external angular process of the frontal bone, and about 1¾ inches above the zygomatic arch.

The **asterion,** or point where the parieto-mastoid, occipito-mastoid, and lambdoid sutures meet, is situated about 2 inches behind the auricular point, very nearly in line with the upper border of the zygomatic arch.

The **sagittal line** represents the line which connects the nasion, or meeting of the two fronto-nasal sutures, with the inion.

The **sagittal suture** corresponds to that part of the sagittal line which extends from the lambda to the bregma.

The **coronal suture** is indicated on either side by a line extending from the bregma to the pterion.

The **lambdoid suture** (occipito-parietal) corresponds to a line extending from the lambda to the asterion.

The **squamo-parietal suture,** and its continuation backwards as the parieto-mastoid suture, are indicated by a curved line, with the convexity upwards, extending from the pterion to the asterion, the highest part of the curve being about 2 inches above the zygomatic arch.

The **superior longitudinal sinus** corresponds to a line drawn from the glabella to the inion, or external occipital protuberance. For the most part it occupies the median line, but, as it grooves the upper portion of the tabular part of the occipital bone, it deviates to one side, most commonly the right side.

The **torcular Herophili** is usually situated on the right side of the inion.

The **occipital sinus** corresponds to a line drawn downwards from the inion.

The **lateral sinus** is indicated by a curved line drawn from the inion outwards and forwards to the base of the mastoid process of the temporal bone on a level with the upper margin of the orifice of the meatus auditorius externus. From this point the line passes in a curved manner downwards and inwards over the back of the mastoid process towards its tip, as far as a point about $\frac{1}{4}$ inch below the level of the lower margin of the orifice of the meatus auditorius externus. Beyond this point the line passes forwards to the position of the jugular foramen. A ready guide to the position of the sigmoid or mastoid portion of the lateral sinus is the line of reflection of the skin from the auricle on to the head. The lateral sinus may be readily opened at a point 1 inch behind the meatus auditorius externus, on a level with the upper margin of its orifice.

The large **anterior division of the middle meningeal artery,** as it lies in the groove, or, it may be, short canal, on the internal aspect of the antero-inferior angle of the parietal bone, is indicated by taking a point $1\frac{1}{2}$ inches behind the external angular process of the frontal bone, and $1\frac{1}{2}$ inches above the zygomatic arch. From this point it ascends almost vertically towards the sagittal suture, lying about $\frac{1}{2}$ inch behind the coronal suture.

The small **posterior division of the middle meningeal artery** lies about 2 inches behind the anterior division.

The **lower level of the cerebral hemisphere** corresponds approximately to the following line: commencing at a point immediately below the glabella, the line passes outwards in a curved manner, with the convexity upwards, about $\frac{1}{2}$ inch above the supra-orbital arch. It then crosses the temporal ridge of the frontal bone from $\frac{1}{4}$ to $\frac{1}{2}$ inch above the base of the external angular process, after

which it passes backwards and slightly downwards to a point about 1 inch behind the external angular process. The line now passes downwards and backwards to the upper border of the zygomatic arch about its centre. It then passes backwards along the upper border of the arch, lying about ¼ inch above the upper margin of the orifice of the meatus auditorius externus. Thereafter it crosses the supramastoid crest, and follows the line of the lateral sinus to the inion.

The **Sylvian point,** which represents the division of the fissure of

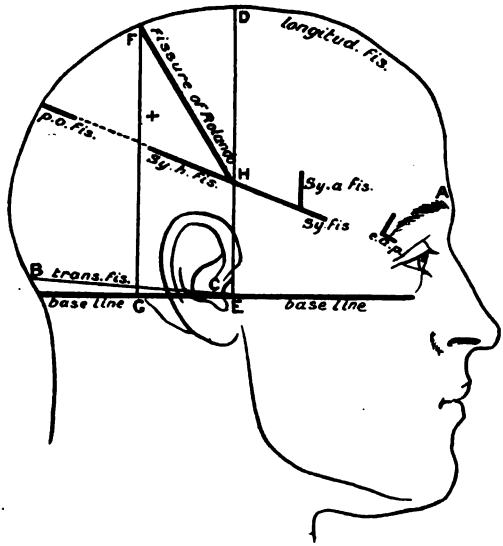


FIG. 598.—DIAGRAM SHOWING THE RELATIONS OF THE CHIEF CEREBRAL FISSURES TO THE EXTERIOR OF THE HEAD (REID).

A. Glabella
B. Inion
C. Auricular Point
E. Pre-auricular Point
F. Superior Rolandic Point
G. Posterior Border of Root of Mastoid Process
H. Inferior Rolandic Point
B.C. Transverse Fissure
D.E., F.G. Reid's Perpendicular Lines
Sy. Fis. Sylvian Fissure
Sy.a. Fis. Anterior Limb of Sylvian Fissure
Sy.h. Fis. Posterior Horizontal Limb of Sylvian Fissure
p.o. Fis. External Parieto-occipital Fissure
+ Parietal Eminence

Sylvius into its three limbs, anterior, ascending, and posterior, is situated on the outer surface of the cerebral hemisphere, and corresponds to the pterion, which, as stated, is situated about 1½ inches behind the external angular process of the frontal bone, and about 1¾ inches above the zygomatic arch. The *anterior limb* of the Sylvian fissure passes horizontally forwards, and the *ascending limb* upwards and slightly forwards, from the Sylvian point, each for about ½ inch. The *posterior limb* corresponds to the **Sylvian line,** which extends from the Sylvian point backwards and slightly upwards

for about 3 inches, and then vertically upwards for about ½ inch to a point ¾ inch below the parietal eminence.

Fissure of Rolando.—The **superior Rolandic point,** which indicates the upper end of the fissure of Rolando, is situated about 2 inches behind the bregma, or about ½ inch behind the centre of the sagittal line, which connects the nasion and the inion.

The **inferior Rolandic point,** which indicates the lower end of the fissure of Rolando, is situated about 2 inches behind and a little above the level of the external angular process, and about

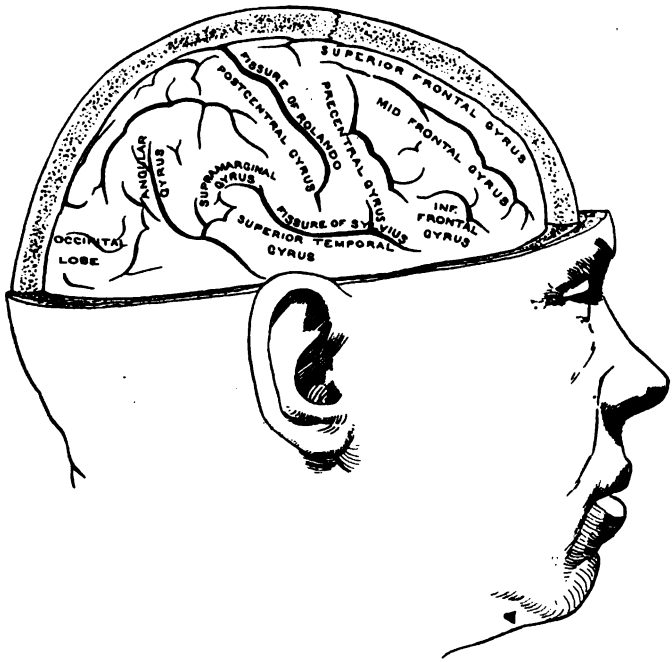


FIG. 599.—THE OUTER SURFACE OF THE RIGHT CEREBRAL HEMISPHERE, SHOWING THE RELATIONS OF ITS GYRI AND FISSURES TO THE EXTERIOR OF THE CRANIUM (FROM A PREPARATION MADE BY THE AUTHOR).

1 inch behind the coronal suture. A line connecting the superior and inferior Rolandic points indicates the fissure of Rolando, which is about 3½ inches in length. This line is called the **Rolandic line,** and it should present two curves, an upper, concave forwards, and a lower, convex forwards. If sufficiently prolonged, the Rolandic line would correspond to about the centre of the zygomatic arch.

Another way to indicate the fissure of Rolando is to utilise **Reid's base line,** which represents a line drawn backwards from the centre of the infra-orbital margin through the auricular point (the centre

of the orifice of the meatus auditorius externus. A point in this line situated in the depression between the tragus of the auricle and the condyle of the inferior maxilla is called the **pre-auricular point.** Two lines are drawn upwards, perpendicular to Reid's base line, one from the pre-auricular point, and the other from the posterior border of the mastoid process close to its root. These two lines, together with the sagittal and Sylvian lines, enclose a quadrilateral area, and the diagonal of this area which connects its postero-superior and antero-inferior angles represents the fissure of Rolando.

The angle which the Rolandic line forms with the sagittal line is called the **Rolandic angle,** and is from 65° to 70°.

THE EYE

THE eyeball is almost spherical. It consists of the segments of two spheres, namely, a large posterior or sclerotic segment, which is opaque, and a small anterior or corneal segment, which is transparent. The sclerotic segment forms five-sixths of the eyeball, and the corneal segment forms one-sixth. The centre of the

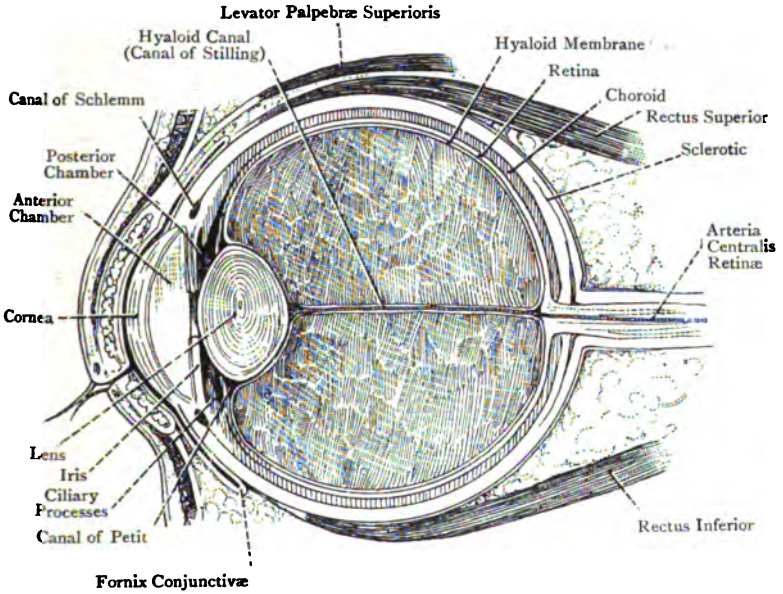


FIG. 600.—VERTICAL SAGITTAL SECTION OF THE EYE AND ITS APPENDAGES (HIRSCHFELD AND LEVEILLÉ).

corneal segment is called the **anterior pole,** and the centre of the sclerotic segment is known as the **posterior pole.** The sagittal (antero-posterior) axis, or **axis of vision,** of the eyeball is represented by a line connecting the anterior and posterior poles. The **equator** is represented by a line encircling the eyeball opposite the centre of the axis of vision, the diameter of the circle being

about 1 inch. The plane of this circle would therefore divide the eyeball into two halves—an anterior half, consisting of the corneal segment and the front part of the sclerotic segment, and a posterior half, consisting of the back part of the sclerotic segment. The **meridian** is represented by a line encircling the eyeball at right angles to the equator, and passing through the anterior and posterior poles.

Posteriorly the eyeball receives the optic nerve, which pierces the sclerotic coat at a point about $\frac{1}{8}$ inch to the inner side of, and about $\frac{1}{24}$ inch below, the posterior pole.

The eyeball is composed of three coats, concentrically arranged, as follows: (1) an *external coat*, consisting of an opaque part, called the **sclerotic**, and a transparent part, called the **cornea**; (2) a *middle coat*, which is vascular, pigmented, and muscular, and consists of (*a*) a posterior part, called the **choroid coat**, (*b*) an anterior part, called the **iris**, and (*c*) an intermediate part, representing the **ciliary body**; and (3) an *internal coat*, called the **retina**.

These three coats enclose a cavity which contains the *refracting media*, these being three in number, as follows: (1) a fluid, called the **aqueous humour**, which lies between the cornea and the crystalline lens, where it occupies the *anterior* and *posterior chambers*, into which this region is divided by the iris; (2) a solid body, called the **crystalline lens**, which lies behind the aqueous humour; and (3) a soft gelatinous body, called the **vitreous body**, which occupies the large space behind the crystalline lens.

Coats of the Eyeball.	**Refracting Media.**
External = sclerotic and cornea.	Aqueous humour.
Middle = choroid, ciliary body, and iris.	Crystalline lens.
Internal = retina.	Vitreous body.

External Coat.

Sclerotic Coat.—The sclerotic (white of the eye) is a strong white fibrous coat of great density, which surrounds the posterior five-sixths of the eyeball, and maintains the shape of the organ. Anteriorly it unites, and becomes continuous, with the cornea, which it slightly overlaps. The junction of the two is indicated by a slight groove, called the *sulcus scleræ*, and the union is known as the *corneo-scleral junction*. Posteriorly the sclerotic is pierced by the optic nerve, this part being known as the *optic entrance*. It is situated, as stated, at a point about $\frac{1}{8}$ inch to the inner side of, and about $\frac{1}{24}$ inch below, the posterior pole of the eyeball. The part of the sclerotic corresponding to the optic entrance is pierced by a number of openings for the passage of the fasciculi of the optic nerve, and is hence called the *lamina cribrosa*.

Around the optic entrance there are numerous minute openings for the ciliary vessels and nerves, and in this situation the dura-matral sheath of the optic nerve blends with the sclerotic. About midway between the optic entrance and the corneo-scleral junction

the sclerotic is pierced by about four openings for the passage of the *venæ vorticosæ*.

The sclerotic is thickest posteriorly around the optic entrance. It is also thick near the corneo-scleral junction, where it gives insertion to the recti muscles, from the tendinous expansions of which it receives accessions of fibres.

The *outer surface* of the sclerotic is covered by a membranous investment, called the **capsule of Tenon,** and between the two there is the **perisclerotic lymph-space** or **Tenon's space,** which is broken up into a reticulum by processes of connective tissue which pass between the capsule of Tenon and the sclerotic. This space communicates with the subdural and subarachnoid spaces. The *inner surface* is of a dark brown colour, and presents grooves for the ciliary vessels and nerves. It is lined with connective tissue containing pigment cells, this layer being called the **lamina fusca.** Processes from this layer pass to be attached to the choroid coat, and these processes, together with vessels and nerves, traverse an interval, which represents the **perichoroidal lymph-space.** This space communicates with the perisclerotic lymph-space through the vascular openings in the sclerotic. *Anteriorly* the sclerotic blends with the cornea at the corneo-scleral junction, the sclerotic slightly overlapping the cornea. *Posteriorly*, around the optic entrance the sclerotic blends with the dura-matral sheath of the optic nerve.

Structure.—The sclerotic is composed of fibrous tissue, mixed with elastic fibres, and it contains many connective-tissue corpuscles. The fibres are arranged in bundles, which are disposed longitudinally and transversely, and interlace with one another. The connective-tissue corpuscles occupy spaces between the fibres, which may be regarded as lymph-spaces.

Arteries.—These are the short ciliary group of posterior ciliary arteries, and the anterior ciliary arteries, which are branches of the ophthalmic artery. The vessels belonging to the former group are disposed in the form of capillary networks; whilst the vessels derived from the latter form a ring near the corneo-scleral junction beneath the conjunctiva, to which ring they converge in the substance of the sclerotic.

The sclerotic **veins** open into the anterior ciliary veins, and into the *venæ vorticosæ*.

Nerve-supply.—The ciliary nerves.

The capsule of Tenon will be found described on p. 1075.

Cornea.—The cornea is the transparent part of the external coat of the eyeball, of which it forms the anterior sixth, and it serves to transmit light. It is almost circular, its transverse measurement being slightly greater than the vertical. At its circumference it is continuous with the sclerotic, by which it is slightly overlapped. The *anterior surface* is convex. The *posterior surface* is concave, and forms the anterior boundary of the anterior chamber of the eye.

Structure.—The cornea consists of five layers, which are as follows, from before backwards :

1. The conjunctival epithelium.
2. The anterior elastic lamina.
3. The substantia propria.
4. The posterior elastic lamina.
5. A layer of endothelium.

The **conjunctival epithelium** is of the stratified variety, there being not less than six strata of cells, and it is continuous with the epithelium which covers the free surface of the conjunctiva. The

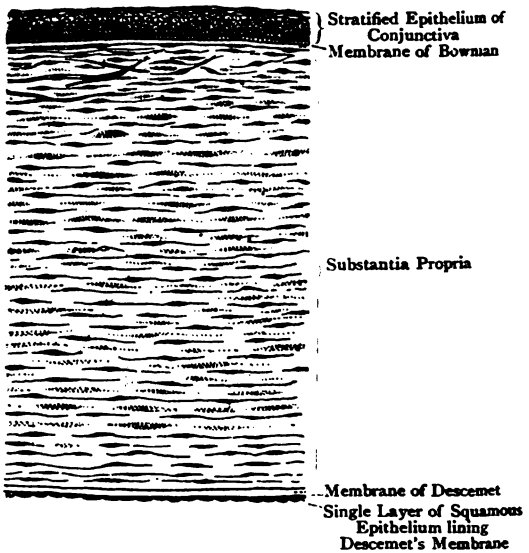

Stratified Epithelium of Conjunctiva
Membrane of Bowman
Substantia Propria
Membrane of Descemet
Single Layer of Squamous Epithelium lining Descemet's Membrane

FIG. 601.—VERTICAL SECTION OF THE CORNEA (MAGNIFIED).

cells of the deepest stratum are columnar ; succeeding to these there are layers of polygonal cells ; and these in turn are overlaid by layers of squamous cells.

The **anterior elastic lamina** (Bowman) is probably of the same nature as the fibrous portion of the substantia propria. It is closely connected with the substantia propria, is thin, and contains no corpuscles.

The **substantia propria** is composed of modified connective tissue, arranged in bundles which form superimposed laminæ. These laminæ amount in number to about sixty. The fibres of alternate laminæ cross each other at right angles, and at the circumference of the cornea they are continuous with the fibres of the sclerotic.

The successive laminæ are connected by cement substance, and within this substance there are branched spaces, called the **corneal spaces** or **lacunæ**, which communicate with each other by very delicate canaliculi. Each of these spaces contains a nucleated connective-tissue corpuscle, called the **corneal corpuscle.** These corpuscles, like the spaces which they occupy, are branched, and the offsets of adjacent corpuscles communicate with one another. As seen in vertical sections of the cornea the corpuscles are spindle-shaped, but in horizontal sections they appear flattened out, and give off their branches.

The **posterior elastic lamina,** or **membrane of Descemet** (*membrane of Demours*), covers the posterior surface of the substantia propria. It is thicker than the anterior elastic lamina, and is composed of an elastic homogeneous membrane, which is very brittle. When stripped from the substantia propria it comes away in shreds, and these curl up at their ends in such a manner that the anterior or attached surface of each shred is turned inwards. At the circumference of the cornea the posterior elastic lamina becomes broken up into fibres. The most posterior of these fibres pass in a radiating and reticular manner into the iris, and they form the ligamentum pectinatum iridis, the intervals between the fibres of which represent the spaces of Fontana.

The **layer of endothelium** lines the posterior surface of the posterior elastic lamina, and consists of one stratum of cells. It is continued over the front of the iris, and into the spaces of Fontana.

The cornea in the adult is non-vascular, except at the circumference, in which situation there are the conjunctival and sclerotic capillaries, which terminate in loops. Being destitute of blood-vessels, the nourishment of the cornea is maintained by the flow of lymph through its substance.

Nerve-supply.—The nerves are derived from the ciliary nerves, and are very numerous. They enter the anterior part of the sclerotic, and form a plexus around the corneo-scleral junction. Offsets from this plexus enter the cornea, and form what is known as the *plexus annularis*. From this plexus delicate offsets are given off, which traverse the substance of the cornea and pass through the anterior elastic lamina. They then give rise to a fine plexus upon the surface of that lamina, called the *subepithelial plexus*. From this plexus, in turn, minute fibrils are given off, which pass amongst the cells of the conjunctival epithelium, and almost reach the surface, forming an **intra-epithelial plexus.**

Ligamentum Pectinatum Iridis.—As stated, the posterior elastic lamina at its circumference breaks up into fibres. The most posterior fibres, which pass in a radiating and recticular manner into the iris, constitute the ligamentum pectinatum iridis, and they are covered by a prolongation of the endothelial layer of the cornea.

Spaces of Fontana.—These spaces represent the irregular intervals which lie between the radiating and reticular fibres of the ligamentum pectinatum iridis. They are lined by a prolongation

of the endothelial layer of the cornea, and they communicate *internally* with the anterior chamber and the lymph spaces within the iris, and *externally* with the canal of Schlemm.

Canal of Schlemm (canal of Fontana, ***sinus circularis iridis***, or *sinus venosus scleræ*).—This canal is situated deeply in the sclerotic, close to the corneo-scleral junction. It communicates *internally* with the anterior chamber through means of the spaces of Fontana, and with the veins of the iris, and *externally* with the veins of the sclerotic.

Middle Coat.

1. **Choroid Coat.**—This is a very vascular, deeply pigmented tunic of a dark brown colour, which lies between the sclerotic and the retina. It extends over the posterior five-sixths of the eyeball,

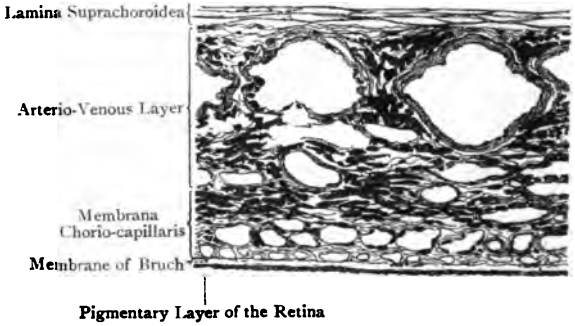


FIG. 602.—VERTICAL SECTION OF THE CHOROID COAT.

(The Pigmentary Layer of the Retina is also shown).

and reaches as far forwards as the ora serrata of the retina. Anteriorly it is connected with the circumference of the iris, and posteriorly it is pierced by the optic nerve. Its *outer surface* is connected to the inner surface of the sclerotic by means of the lamina fusca and its processes, as well as by vessels and nerves which cross the perichoroidal lymph-space. Its *inner surface* is in contact with the pigmentary layer of the retina.

Structure.—The choroid coat consists of connective tissue, bloodvessels, and branched pigment cells. It is composed of three layers, which are as follows, from without inwards: (1) the lamina suprachoroidea; (2) the choroid proper; and (3) the lamina basalis, or membrane of Bruch.

The **lamina suprachoroidea** is composed of delicate, non-vascular lamellæ, each of which is made up of elastic fibres, arranged in a reticular manner, and of branched pigment cells.

The **choroid proper** consists principally of bloodvessels and pig-

ment-cells, supported by connective tissue. The bloodvessels are arranged partly as arteries and veins, and partly as capillaries. The choroid proper is therefore composed of two layers, namely, external or lamina vasculosa, and internal or lamina chorio-capillaris.

The **lamina vasculosa** (arterio-venous layer) is composed of (1) branches of the short ciliary group of the posterior ciliary arteries, which pass forwards before they turn inwards to terminate in capillaries; and (2) veins, which form the chief part of the lamina vasculosa, and are called the **venæ vorticosæ.** These veins are very closely set, and are arranged in a whorled manner. They ultimately converge and form about four vessels, which pierce the sclerotic nearly midway between the optic entrance and the corneo-scleral junction, at points equally distant from each other. Scattered throughout the lamina vasculosa there are branched pigment-cells.

The **lamina chorio-capillaris,** or **tunica Ruyschiana,** is composed of a plexus of capillary bloodvessels, the arteries leading to it being derived from the short ciliary arteries.

The lamina vasculosa and lamina chorio-capillaris are connected by fine elastic fibres, which form what is known as the *stratum intermedium.*

The **lamina basalis,** or **membrane of Bruch,** is situated on the inner surface of the lamina chorio-capillaris, which it separates from the pigmentary layer of the retina. It is a very delicate membrane, without any very definite structure.

Tapetum.—This is present in certain animals. It lies between the lamina vasculosa and the lamina chorio-capillaris in the stratum intermedium, and it gives rise to a rainbow-like appearance. In some animals it is fibrous in structure, and in others cellular.

2. **Ciliary Body.**—The ciliary body, as stated, connects the anterior part of the choroid to the circumference of the iris. It is composed of (1) the orbicularis ciliaris, (2) the ciliary processes, and (3) the ciliary muscle.

The **orbicularis ciliaris** is a narrow zone which lies immediately in front of the anterior part of the choroid, with which it is continuous. It presents plications which are radially disposed, and it separates the ciliary processes from the ora serrata of the retina.

The **ciliary processes,** which are about seventy in number, are projections or infoldings of the anterior part of the choroid, and consist of the choroid proper and the membrane of Bruch. They constitute a series of rays, arranged in a circular manner, and converge as they pass inwards and forwards to the periphery of the crystalline lens on its anterior aspect. They are somewhat conical in outline. Their free extremities, which are round and prominent, lie behind the circumference of the iris upon the anterior aspect of the periphery of the crystalline lens. Their attached extremities are connected with the orbicularis ciliaris.

Anteriorly they are related to the posterior chamber of the eyeball at its circumference. Posteriorly they rest upon the zonule of Zinn, the folds of which fit closely in between them.

Structure.—The ciliary processes are similar in structure to the choroid, but the pigment-cells are not so numerous. On their deep or posterior surfaces the processes are covered by the **pars ciliaris retinæ,** which is prolonged from the pigmentary layer of the retina, and is continuous with the pars iridica retinæ (uvea) on the posterior surface of the iris.

The arteries of the ciliary processes are derived from those of the anterior part of the choroid, and from the anterior ciliary arteries. The veins pass to those of the choroid.

Ciliary Muscle.—This muscle is composed of unstriped fibres. It forms a greyish-white ring, about $\frac{1}{10}$ inch broad, which is

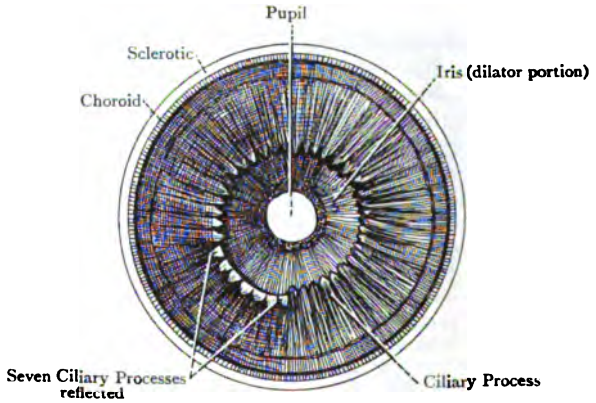


FIG. 603.—THE IRIS AND CILIARY PROCESSES (POSTERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

situated at the anterior part of the choroid, opposite the ciliary processes. The fibres are arranged in two sets—radial and circular. The *radial fibres* arise from the deep surface of the sclerotic, close to the corneo-scleral junction, and behind the canal of Schlemm. From this origin they pass backwards in a radiating manner, and are inserted into the orbicularis ciliaris and the attached ends of the ciliary processes. The *circular fibres* form a ring around the circumference of the iris, internal to the radial fibres.

The ciliary muscle is supplied by the ciliary nerves, which are branches of the ciliary ganglion.

Action.—The ciliary muscle is the muscle of *accommodation,* and adjusts the eye to the vision of near objects. When it contracts it draws forwards the choroid and the ciliary processes ; the suspensory ligament of the crystalline lens is thereby relaxed ; and, as a consequence, the anterior surface of the lens is rendered convex.

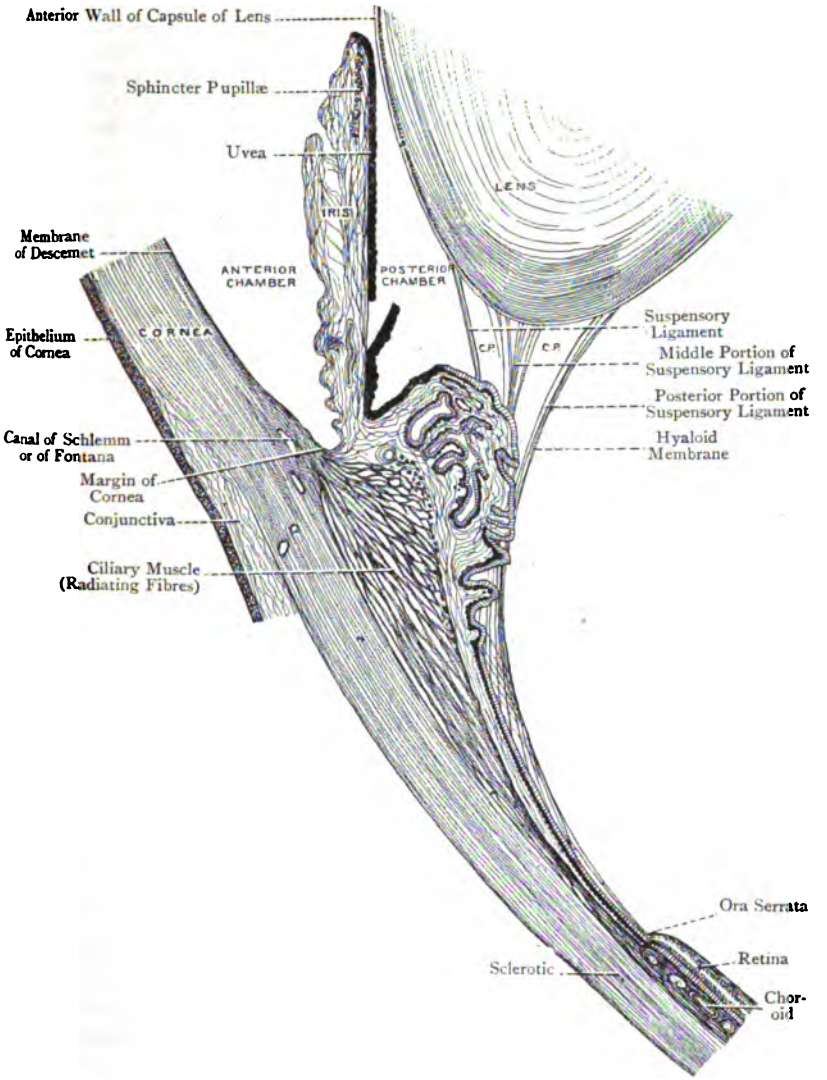


FIG. 604.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE (MAGNIFIED 16 × 1) (FUCHS).

C.P., C.P., Canal of Petit.

The circular fibres of the ciliary muscle are well developed in cases of hypermetropia, but are deficient in cases of myopia.

3. **Iris.**—The iris forms the anterior part of the middle coat of the eyeball. It is a coloured contractile curtain, which is suspended in the aqueous humour between the cornea and the crystalline lens. It is perforated by an almost circular aperture, called the **pupil,** which is situated slightly to the nasal or inner side of its centre, and serves for the transmission of light. The margin which surrounds the pupil is known as the *pupillary margin.* Its circumference is continuous with the ciliary body, and is connected with the posterior elastic lamina of the cornea by means of the ligamentum pectinatum iridis. The circumference is known as the *ciliary margin.* The surfaces of the iris are anterior and posterior. The *anterior surface* is directed towards the cornea. Its colour varies in different individuals, and it presents a striated appearance, the striæ converging towards the margin of the pupil, and being produced by the underlying vessels. The *posterior surface* is directed towards the crystalline lens and ciliary processes. It has a purple colour, and is covered by two layers of columnar epithelium, the cells of which contain dark pigment. These two layers of pigmented cells constitute the **pars iridica retinæ** (*uvea*), which is continuous with the pars ciliaris retinæ. The iris divides the space between the cornea and the crystalline lens into two compartments, the anterior chamber and posterior chamber, both of which contain the aqueous humour.

Structure.—The component parts of the iris are as follows: (1) a layer of endothelium; (2) a connective-tissue stroma, with branched cells; (3) muscular tissue; and (4) pigment.

The **layer of endothelium** covers the anterior surface of the iris, and is continuous with the endothelium which lines the posterior elastic lamina (membrane of Descemet) of the cornea.

The **connective-tissue stroma** is composed of fibres which, for the most part, pass in a radiating manner towards the pupillary margin. Some, however, are disposed circularly at the ciliary margin. They support the bloodvessels and nerves, and scattered between their bundles there are branched cells. These cells contain pigment in dark coloured eyes (black, grey, or brown), but in blue eyes they are destitute of pigment.

The muscular tissue is of the unstriped variety, and its fibres are arranged in two sets, circular and radiating. The *circular fibres* form a ring round the pupil, and are nearer the posterior surface than the anterior. They are known as the **sphincter pupillæ.** The *radiating fibres* converge from the ciliary margin of the iris towards the pupillary margin, where they blend with the circular fibres. The radiating fibres constitute the **dilator pupillæ.** Some authorities regard the radiating fibres as being elastic, and not muscular.

The **pigment** of the iris is variously situated, according to the colour of the eye. In the eyes of albinos there is no pigment.

In other eyes pigment is contained in the cells of the two layers of columnar epithelium which line the posterior surface of the iris, and form the pars iridica retinæ (uvea). In blue eyes the pigment is confined to this region, but in dark coloured eyes (black, grey, or brown), it is also present in the branched cells of the connective-tissue stroma.

Blood-supply—Arteries.—The arteries of the iris are derived from (1) the long ciliary, and (2) the anterior ciliary, vessels.

The **long ciliary arteries** are two in number, and belong to the posterior ciliary group of branches from the ophthalmic artery. They pierce the back part of the sclerotic, one on each side of the optic nerve, and pass forwards between the sclerotic and the choroid towards the ciliary margin of the iris. Here each vessel divides into two branches, upper and lower, which anastomose with those of the opposite side to form an arterial ring round the ciliary margin of the iris, called the *circulus major*. This ring is joined by some

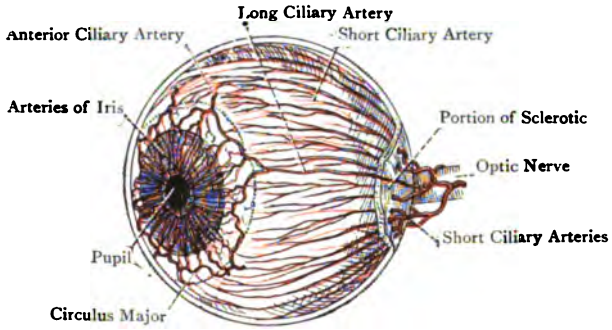


FIG. 605.—THE ARTERIES OF THE CHOROID AND IRIS (LATERAL VIEW).

of the anterior ciliary arteries, and it gives offsets to the ciliary muscle and iris. The branches which enter the iris are supported by the connective-tissue stroma, and converge towards the pupillary margin, near which they form by their anastomoses another arterial ring, called the *circulus minor*.

The **anterior ciliary arteries** are about six in number, and are derived from the muscular and lachrymal branches of the ophthalmic artery. They are of small size and pierce the anterior part of the sclerotic, close to the corneo-scleral junction. Some of them supply the ciliary processes, and others join the circulus major.

The **veins** of the iris accompany the arteries, and are in communication with the canal of Schlemm.

Nerves of the Choroid Coat and Iris.—These are derived from the ciliary nerves, short and long, the former coming from the ciliary ganglion, and the latter from the nasal branch of the

ophthalmic or first division of the fifth cranial nerve. They are about sixteen in number, and pierce the back part of the sclerotic around the optic nerve. They then pass forwards between the sclerotic and choroid, giving branches to the latter coat, which become disposed in a plexiform manner amongst the bloodvessels. Having reached the corneo-scleral junction, the nerves enter the ciliary muscle, in which they form a plexus. From this plexus branches enter the iris at the ciliary margin. These branches accompany the vessels, and, by their subdivisions and communications, they form a copious plexus of non-medullated fibres in the connective-tissue stroma of the iris. The **sphincter pupillæ** is supplied by fibres which are derived from the oculo-motor or third

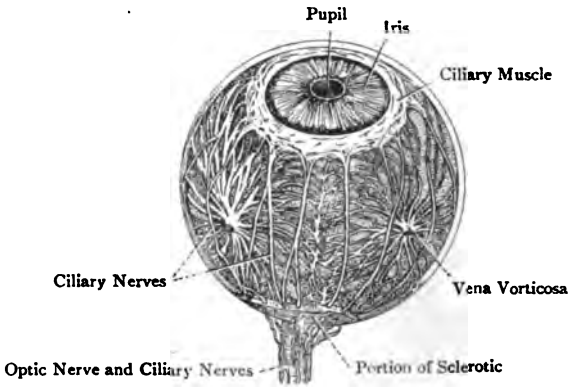


FIG. 606.—THE CHOROID AND IRIS, SHOWING THE VENÆ VORTICOSÆ AND CILIARY NERVES (AFTER HIRSCHFELD AND LEVEILLÉ).

(The Sclerotic and Cornea have been removed).

cranial nerve, through means of the motor root of the ciliary ganglion. The **dilator pupillæ** is supplied by fibres which are derived from the sympathetic through means of the sympathetic root of the ciliary ganglion.

Membrana Pupillaris.—During intra-uterine life the pupil is closed by a delicate membrane, called the **membrana pupillaris.** This membrane is vascular, except at its centre, the arteries being derived from the circulus minor, and from those of the front part of the capsule of the crystalline lens. The vessels converge from the circumference of the membrane to near its centre, and terminate by forming loops.

The membrana pupillaris disappears shortly before birth.

Internal Coat.

Retina.—The retina is the internal or nervous tunic of the eyeball. It is soft in consistence, translucent, and of a pinkish colour. Its internal surface is in contact with the hyaloid membrane,

which encloses the vitreous body, and its external surface is in contact with the choroid coat. Posteriorly it receives the fibres of the optic nerve. Anteriorly it extends almost to the ciliary body, where it presents a notched border, called the **ora serrata.** Here its nervous elements terminate, but its pigmentary layer is continued over the deep or posterior surfaces of the ciliary processes on to the posterior surface of the iris, forming, with the addition of a layer of columnar epithelial cells, the pars ciliaris retinæ and pars iridica retinæ (uvea), respectively. The retina diminishes in thickness from behind forwards.

The *external surface* is formed by a stratum of hexagonal pigment-cells, which send processes into the adjacent layer. When the

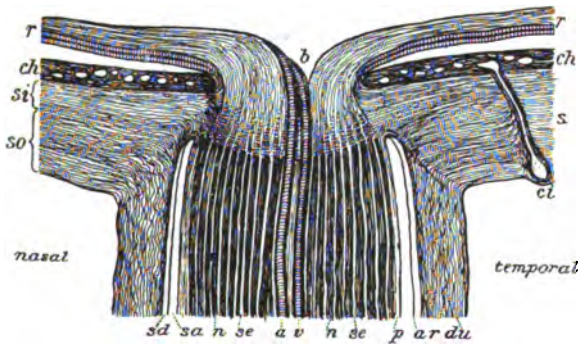


FIG. 607.—LONGITUDINAL SECTION THROUGH THE HEAD OF THE OPTIC NERVE (14 × 1) (FUCHS).

r. Retina
b. Centre of Porus Opticus
ch. Choroid
s. Sclerotic
so. Outer Part of Sclerotic
si. Inner Part of Sclerotic
ci. Ciliary Artery (in longitudinal section)
sd. Subdural Space
sa. Subarachnoid Space
n. Bundles of Nerve-fibres
se. Septa between the Nerve-bundles
a. Arteria Centralis Retinæ
v. Vena Centralis Retinæ
p. Sheath formed by Pia Mater
ar. Sheath formed by Arachnoid
du. Sheath formed by Dura Mater

nasal, Inner Side. temporal, Outer Side

choroid is separated from the retina these processes are torn, and the stratum of pigment-cells remains attached to the choroid, being apparently a part of it. The pigmentary layer, however, really belongs to the retina.

The *internal surface* presents, in the line of the visual axis of the eyeball, the **macula lutea** or **yellow spot,** where vision is most distinct. This spot is transversely oval, and measures about $\frac{1}{12}$ inch in the transverse diameter. At its centre there is a slight depression, called the **fovea centralis.** In this situation the retina is thinnest, and the dark colour of the hexagonal pigment-cells is visible through it, imparting to it the appearance of a foramen. About $\frac{1}{8}$ inch to the inner side of the posterior pole of the

eyeball, and about $\frac{1}{24}$ inch below its level, is the **porus opticus, or optic disc.** This is circular in outline, and its circumference is slightly elevated. It represents the point of entrance of the fibres of the optic nerve, and the centre of the disc is pierced by the arteria centralis retinæ, which immediately divides into two branches—upper and lower. The optic disc consists entirely of nerve-fibres, and is known as the 'blind spot,' vision being absent in this situation.

Structure of the Retina.—The retina consists of eight superimposed layers, seven of which are nervous and one pigmentary.

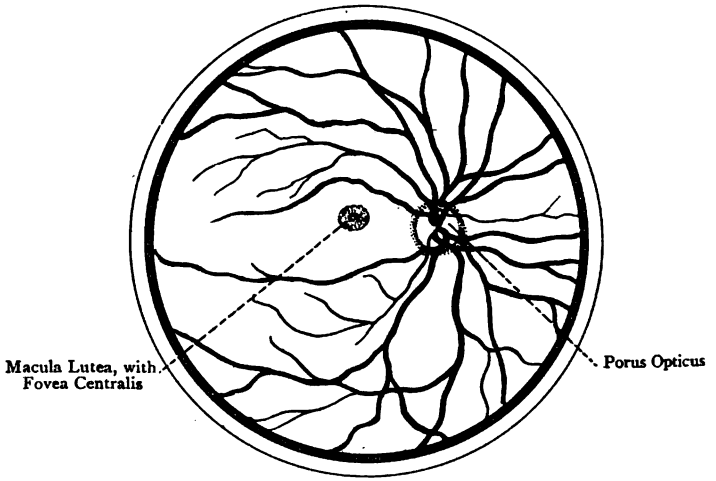


FIG. 608.—THE POSTERIOR PORTION OF THE RIGHT RETINA (ANTERIOR VIEW).

In addition to these, there are sustentacular fibres. The eight layers are as follows, from within outwards :

1. Stratum opticum, or layer of nerve-fibres.
2. Ganglionic layer, or layer of nerve-cells.
3. Inner molecular (inner plexiform) layer.
4. Inner nuclear or granular layer.
5. Outer molecular (outer plexiform) layer.
6. Outer nuclear or granular layer.
7. Layer of rods and cones, or bacillary layer.
8. Pigmentary layer.

In addition to the foregoing layers, there are two very delicate membranes, which really belong to the sustentacular fibres of the retina, but are known as the membrana limitans interna and membrana limitans externa. The **membrana limitans interna** covers the retina on its internal surface, and the **membrana limitans**

externa intervenes between the outer nuclear layer and the bacillary layer. The layers of the retina are supported by fibres called the **sustentacular fibres.**

1. **Stratum Opticum.**—This layer consists of the fibres of the optic nerve, and it extends from the optic disc to the ora serrata. The fibres are non-medullated, and are chiefly centripetal, but some are centrifugal. The centripetal fibres arise mainly as the axons of

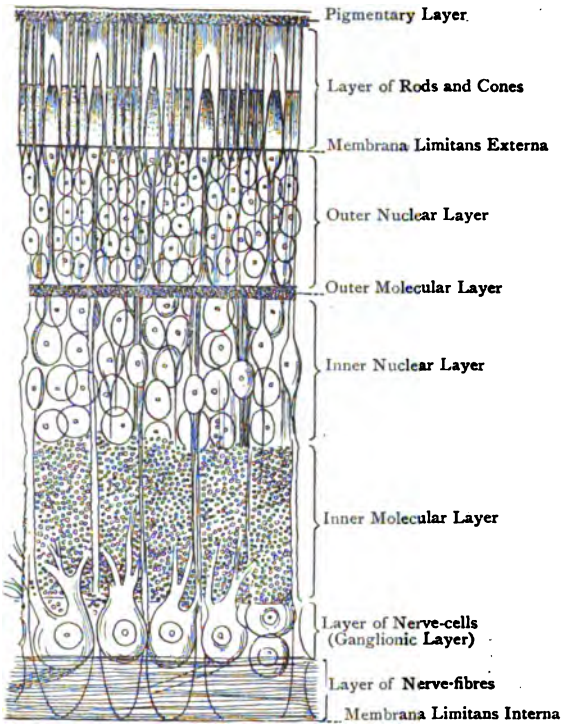


FIG. 609.—DIAGRAMMATIC SECTION OF THE HUMAN RETINA (SCHULTZE).
(Copied from Quain's 'Anatomy').

the cells of the ganglionic layer. The centrifugal fibres pass towards the inner molecular and inner nuclear layers.

2. **Ganglionic Layer.**—This layer consists of large, somewhat flask-shaped, multipolar ganglion-cells, which for the most part form a single layer. In the macula lutea, however, they form several layers. The round ends of the cells rest upon the stratum opticum, and from each of these ends an axon is given off, which enters the stratum opticum obliquely, and forms one of its component fibres. The tapering end of each cell sends off several dendrites, which enter

the inner molecular layer, within which they terminate in arborizations.

3. **Inner Molecular (Inner Plexiform) Layer.**—This layer consists of the arborizations of the dendrites of (1) the cells of the ganglionic layer, and (2) the bipolar cells of the inner nuclear layer. The intercommunications between these two sets of dendrites give rise to five strata, according to Ramon y Cajal. Besides these, there are the arborizations of the processes of the spongioblasts of the inner nuclear layer, which are likewise arranged in strata.

4. **Inner Nuclear or Granular Layer.**—This layer consists of cells which are arranged in three groups, namely, (1) bipolar cells, (2) horizontal cells, and (3) spongioblasts, or amacrine cells. The

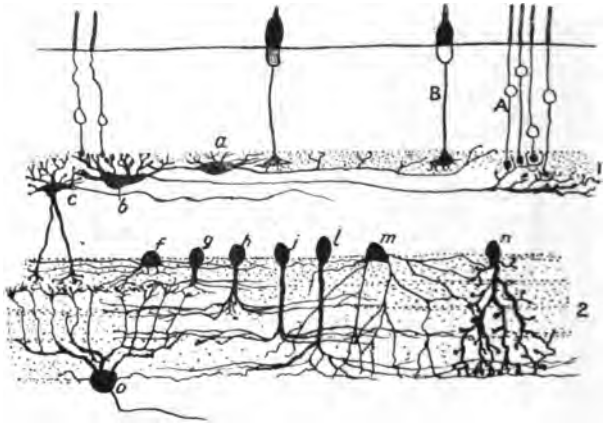


FIG. 610.—SCHEME OF THE HORIZONTAL CELLS AND SPONGIOBLASTS OF THE RETINA (RAMON Y CAJAL).

A. Rod-fibres
B. Cone-fibres
1. Outer Molecular Layer
a, *b*. Horizontal Cells, with arborizations
c. Horizontal Cell, with deep processes
2. Inner Molecular Layer
f, *g*, *h*, *i*, *j*, *l*. Spongioblasts extending to different depths
m, *n*. Spongioblasts with diffuse processes
o. Ganglionic Nerve-cell

bipolar cells are the most numerous, and are nucleated. Each cell gives off two processes—internal and external. The *internal processes* of the cells enter the inner molecular layer, and terminate at different levels in arborizations. The *external processes* pass into the outer molecular layer, and terminate in arborizations in its outermost part, which are closely related to the terminal parts of the rods and cones of the bacillary layer. According to Cajal, the bipolar cells are of two kinds—rod-bipolars and cone-bipolars. The external processes of the **rod-bipolars** ramify around the terminal parts of the rod-fibres, and the internal processes arborize around the cells of the ganglionic layer. The external processes of the **cone-bipolars** form horizontal arborizations around the terminal

parts of the cone-fibres, and the internal processes terminate in arborizations in the inner molecular layer at different levels.

The **horizontal cells** occupy the outer part of the inner nuclear layer. Their dendrites enter the outer molecular layer, and come into relation with the terminal parts of the cone-fibres, whilst their axons run in a horizontal direction.

The **spongioblasts** are situated in the innermost part of the inner nuclear layer. They are destitute of axons, and have been called *amacrine cells*, because each cell is 'without a long fibre or process.' Their dendrites enter the inner molecular layer, and terminate in arborizations, which are arranged in strata.

5. **Outer Molecular (Outer Plexiform) Layer.**—This layer is composed of the following structures: (1) the external processes of the

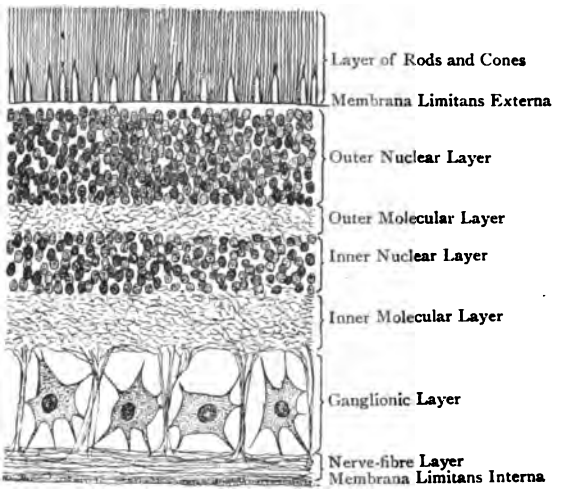


FIG. 611.—SECTION OF THE RETINA AS SEEN UNDER THE MICROSCOPE (MAGNIFIED).

rod-bipolars and cone-bipolars of the inner nuclear layer; (2) the dendrites of the horizontal cells of the inner nuclear layer; and (3) the terminal parts of the rod-fibres, and filaments from the foot-plates of the cone-fibres.

6. **Outer Nuclear or Granular Layer.**—This consists of granules, which are of two kinds, namely, rod-granules and cone-granules. The **rod-granules** are the more numerous, and are oval enlargements in the course of the rod-fibres, as these pass to the outer molecular layer. Each rod-fibre has only one rod-granule, and the granules lie at different levels. Each granule has a nucleus, which presents transverse striations, there being at least two clear bands. The external process of each rod-granule is continuous with one of the rods of the bacillary layer, and the internal process passes into the

outer molecular layer, where it comes into relation with the arborizations of the external process of a rod-bipolar.

The **cone-granules** are larger than the rod-granules, but not so numerous, and each contains an oval nucleus. They are situated in the outermost part of the outer nuclear layer, close to the membrana limitans externa. The outer end of each granule is continuous with one of the cones of the bacillary layer. The inner end is prolonged into a cone-fibre, which passes into the outermost part of the outer molecular layer, where it expands into a foot-plate, from which filaments are given off. These filaments come into relation with the arborizations of the external process of a cone-bipolar cell.

7. **Layer of Rods and Cones, or Bacillary Layer.**—This layer consists of two elements, namely, rods and cones, the former being cylindrical, and the latter flask-shaped. The rods are much more numerous, longer, and narrower than the cones, and both are placed perpendicularly.

Each **rod** and **cone** consists of two segments—outer and inner. In the case of the **rods** the two segments are of almost equal length, the inner segment being rather larger than the outer. The outer segment is the only seat of the colouring matter known as *visual purple* or *rhodopsin*. In the case of the **cones,** which, as stated, are flask-shaped, the *inner* segment of each forms two-thirds of the cone, and is of large size ; whilst the *outer* segment forms one-third, is narrow, and represents the tapering part of the flask. The outer segments of both rods and cones present faint transverse striations. The inner segments of both are subdivided into two parts—outer and inner. The outer part is composed of delicate fibrils, longitudinally arranged, and therefore presents a longitudinally striated appearance. The inner part is faintly granular. The rods and cones are continued at their inner ends through the membrana limitans externa into the rod-fibres and cone-fibres, which belong to the outer nuclear layer. The outer ends of the rods project into the pigmentary layer.

8. **Pigmentary Layer.**—This is the most external layer of the retina, and it is in close contact with the choroid coat. It consists of a single layer of hexagonal epithelial cells, which contain pigment. The deep surfaces of the cells give off processes which extend into the intervals between the outer ends of the rods and cones.

Sustentacular Fibres, or Fibres of Müller.—These fibres constitute the supporting tissue of the retina, and extend from its internal surface to the boundary-line between the outer nuclear layer and the layer of rods and cones. The inner ends of the fibres are expanded, and cohere by their edges so as to present the appearance of a distinct retinal layer, which is called the **membrana limitans interna.** Their outer ends, which are very numerous owing to the breaking up of the fibres, also expand, and form what is known as the **membrana limitans externa,** which lies between the outer nuclear layer and the layer of rods and cones. (The membrana limitans

interna and membrana limitans externa are sometimes counted as layers of the retina, under which circumstances the retinal layers would be *ten* in number, instead of eight, as stated). From the membrana limitans externa delicate offsets enter the layer of rods and cones, in the innermost part of which they form *fibre-baskets* in connection with the deep ends of the rods and cones. As the sustentacular fibres pass through the inner nuclear layer each presents an oval nucleus, which contains a nucleolus. This nucleus is variously described as being situated on one side of the fibre, or as involving its whole circumference. Throughout their course the sustentacular

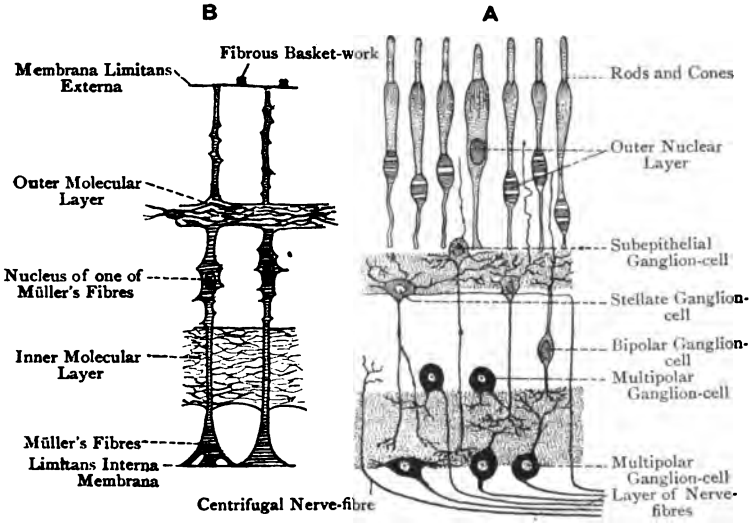


FIG. 612.—DIAGRAM OF THE ELEMENTS OF THE RETINA (WIEDERSHEIM, AFTER PH. STÖHR).

A, Nervous Elements; B, Supporting Elements.

fibres give off lateral offsets, which increase in number from within outwards.

Structure of the Macula Lutea and Fovea Centralis.—The chief structural characters of the macula lutea and fovea centralis may be stated in the following tabular manner :

Macula Lutea.	Fovea Centralis.
1. Cones only.	1. Thinnest part of the retina.
2. Outer nuclear layer has only cone-fibres, disposed obliquely.	2. Pigmentary layer thick.
3. Ganglionic layer very thick, cells being several layers deep.	3. Cones only.
4. Stratum opticum not continuously disposed.	4. Outer nuclear layer has only cone-fibres.
	5. Ganglionic layer absent.
	6. Stratum opticum absent.

Structure of the Ora Serrata.—At the ora serrata, as previously stated, the nervous elements of the retina terminate, and its pigmentary layer is continued over the deep or posterior surfaces of the ciliary processes. In this latter situation there is superadded to its deep or posterior surface a layer of columnar epithelial cells, and the two layers form the pars ciliaris retinæ, which is continued

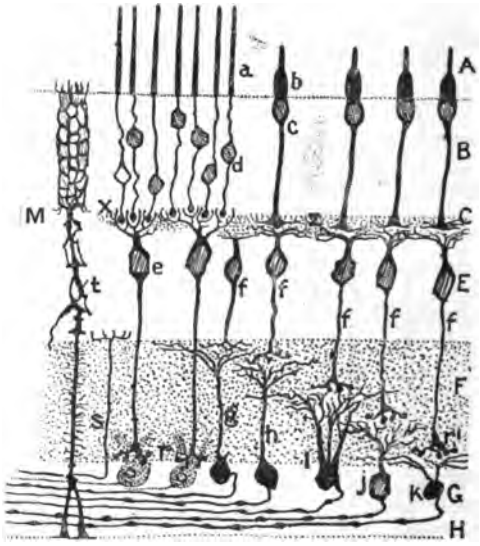


FIG. 613.—SCHEME OF THE RETINA, SHOWING THE CONNECTION BETWEEN THE LAYER OF RODS AND CONES AND THE GANGLIONIC LAYER (RAMON Y CAJAL).

A. Layer of Rods and Cones
B. Outer Nuclear Layer
C. Outer Molecular Layer
E. Inner Nuclear Layer
F. Inner Molecular Layer
G. Ganglionic Layer
H. Layer of Nerve-fibres
M. Müller's Fibre
a. Rods
b. Cones
c. Granule of Cones
d. Granule of Rods
e. Bipolar Cells of Rods
f. Bipolar Cells of Cones
g, h, i, j, k. Ganglionic Corpuscles ramifying at different levels in Inner Molecular Layer
r, r1. Deep arborizations of Bipolar Cells
s. Centrifugal Nerve-fibre
t. Nucleus of Müller's Fibre
X. Deep ends of Rod-fibres amongst superficial arborizations of Bipolar Cells
Z. Meeting of arborizations of Cones and Bipolar Cells

into the pars iridica retinæ (uvea). In the latter the cells of both layers are pigmented.

Blood-supply of the Retina.—The retina is supplied with blood by the **arteria centralis retinæ,** which is a branch of the ophthalmic artery. Within the orbit the artery pierces the under aspect of the optic nerve a little behind the eyeball, and passes forwards in the centre of the nerve. It makes its appearance at the centre of the optic disc, and then divides into two branches, upper and lower.

Each of these breaks up into two branches, nasal or internal, and temporal or external. The temporal branches keep clear of the macula lutea, but furnish small twigs to it, which, however, do not enter the fovea centralis, this part being non-vascular. As the branches pass inwards and outwards, respectively, towards the periphery of the retina, they ramify freely, and ultimately terminate in capillary networks. The arteries do not extend farther outwards than the inner nuclear layer. No anastomoses take place between the branches of the arteria centralis retinæ.

In the fœtus the arteria centralis retinæ furnishes a branch to the posterior part of the capsule of the crystalline lens, which reaches it through the canal of Stilling in the vitreous body.

The **veins** are ultimately collected into two vessels, upper and lower, which pass through the optic disc, one above, and the other below, the artery. They then form one vessel which opens into the superior ophthalmic vein. The veins of the retina are destitute of muscular tissue, the wall of each being formed by a single layer of endothelial cells, external to which there is a perivascular lymph-space, this, in turn, being limited by another layer of endothelial cells. These lymph-spaces are in communication with those of the optic nerve.

Relation of the retinal layers to one another.—The only two layers which are in direct continuity are the stratum opticum and ganglionic layer, some fibres of the former being the axons of the cells of the latter. As regards most of the strata, the constituent elements of successive layers are brought into communication by means of the interlacements which take place between the arborizations formed by their various processes. These interlacements occur in the inner and outer molecular layers.

In the **inner molecular layer** there are several strata of interlacements, by means of which the dendrites of the cells of the ganglionic layer are brought into communication with the internal processes of the bipolar cells of the inner nuclear layer. In the **outer molecular layer** there is a free intermingling between the external processes of the bipolar cells of the inner nuclear layer and the rod-fibres and cone-fibres.

Nerve-cells of the Retina.—These are arranged in three strata, and are in communication with one another through interlacing arborizations. The outermost stratum consists of the rods and cones; the middle stratum is formed by the bipolar cells; and the innermost stratum represents the cells of the ganglionic layer. The axons of the ganglionic cells enter the stratum opticum as centripetal fibres, which pass in the optic nerve to the brain. The centrifugal fibres of the stratum opticum ramify in the inner molecular or inner nuclear layer.

Refracting Media.

Aqueous Humour and Chambers of the Eye.—The aqueous humour occupies the space between the cornea and the front of the crystalline lens, which is divided by the iris into two chambers, anterior and posterior. It is a clear fluid, having an alkaline reaction, and is composed of H_2O, holding in solution a very small amount of sodium chloride.

The **anterior chamber** is bounded anteriorly by the cornea, and posteriorly by the iris and the central portion of the crystalline

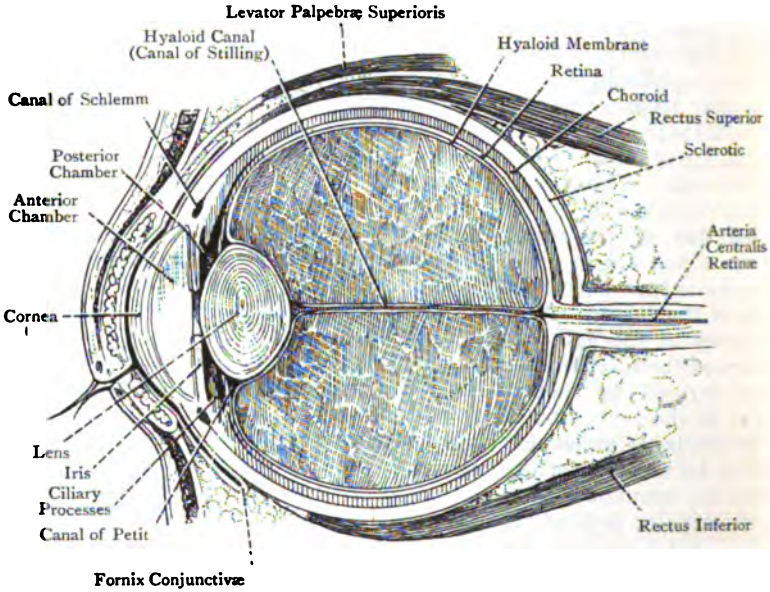


FIG. 614.—VERTICAL SAGITTAL SECTION OF THE EYE AND ITS APPENDAGES (HIRSCHFELD AND LEVEILLÉ).

lens, enclosed within its capsule. The anterior chamber communicates with the spaces of Fontana, through them with the canal of Schlemm, and through this canal with the veins of the sclerotic.

The **posterior chamber,** which is of limited extent, is bounded anteriorly by the iris, and posteriorly by the peripheral part of the crystalline lens and its suspensory ligament, and by the ciliary processes. The anterior and posterior chambers communicate with each other through the pupil ; with lymph-spaces in the iris ; and, through the latter spaces, with the perichoroidal lymph-space.

Crystalline Lens.—The crystalline lens is situated directly behind the pupil and iris, from which latter it is separated by the posterior chamber. It is a solid, transparent, biconvex body, the posterior surface being more convex than the anterior, and it is enclosed within a homogeneous, transparent envelope, called the **capsule** of the lens. The centre of the anterior surface is called the **anterior pole,** and that of the posterior surface the **posterior pole.** The line connecting these two poles constitutes the **axis** of the lens, and a line surrounding the periphery represents the **equator.** The transverse measurement of the lens is about $\frac{1}{3}$ inch, and its axis measures about $\frac{1}{6}$ inch. The *anterior surface* at its central part faces the pupil. External to this, the pupillary margin of the iris rests upon it, and, external to this again, is the posterior chamber,

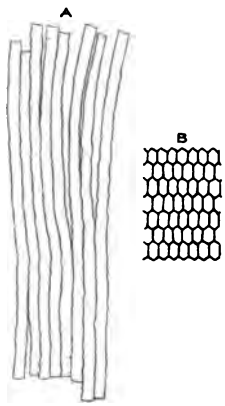


FIG. 615.—FIBRES OF THE CRYSTALLINE LENS (HIGHLY MAGNIFIED) (AFTER KOLLIKER).

A, Fibres of the Ox (seen on edge); B, Human fibres (seen on end).

with part of the aqueous humour. The *posterior surface* is received into the patellar fossa on the anterior aspect of the vitreous body. The *periphery* is related to the suspensory ligament, the canal of Petit, and the ciliary processes. From the anterior and posterior poles delicate lines radiate towards the equator. In early life these are three in number on each surface. Those on the anterior surface are directed as follows: one vertically upwards, and the other two downwards and outwards in a diverging manner, thus ⅄. Those on the posterior surface are directed as follows: one vertically downwards, and the other two upwards and outwards in a diverging manner, thus Y. These lines represent the free margins of septa within the lens, upon which the ends of the lens-fibres terminate.

Structure.—The lens is laminar in structure. The outer laminæ are soft in consistence, but the succeeding ones gradually become

firmer, and the central portion, which constitutes the **nucleus,** is very firm and hard. The laminæ are arranged concentrically, and, after boiling or immersion in alcohol, they may be peeled off, like the coats of an onion. The fibres of which the laminæ are composed terminate upon septa within the lens, of which septa the radiating lines on the surfaces, already referred to, are the free margins. The concentric laminæ are therefore not continuous all round, but are split up along these lines. The **lens-fibres,** which are disposed in a curved manner, are of small size, and have serrated edges, which fit closely to each other. In transverse section the fibres appear as hexagonal prisms. The fibres are the elongated cells which line the posterior part of the epiblastic vesicle (lens vesicle), from which the lens is developed. In early life each fibre has a nucleus, but, after the lens has attained its full development, only the outermost fibres are nucleated.

The lens is non-vascular in the adult.

Capsule of the Lens.—This is a transparent, homogeneous, elastic, and brittle membrane, which surrounds and encloses the lens. Its anterior wall is thicker and more elastic than the posterior. In the adult it is non-vascular, but in the fœtus it receives the hyaloid branch of the arteria centralis retinæ, which reaches it through the canal of Stilling in the vitreous body.

Epithelium of the Lens.—The *posterior* surface of the lens is devoid of epithelium, and is in direct contact with the posterior wall of the capsule. The *anterior* surface is covered by a single layer of columnar cells, which intervenes between the anterior surface and the anterior wall of the capsule. Towards the equator these cells become elongated, and pass into short fibres, which become continuous with the superficial lens-fibres.

Crystalline Lens at Different Ages.—The characters of the lens at different ages are as follows :

Fœtal Lens.	Adult Lens.	Lens in Old Age.
Almost spherical.	Biconvex.	Flattened.
Pinkish colour.	Colourless.	Amber colour.
Semitransparent.	Transparent.	Opaque, more or less.
Soft in consistence.	Firm in consistence.	Very firm in consistence.

Vitreous Body.—This body occupies about four-fifths of the space within the eyeball, and is situated between the crystalline lens and the retina. It is transparent, and gelatinous in consistence, and is composed of H_2O, holding in solution a small quantity of sodium chloride and albuminous matter. It is surrounded by a transparent, homogeneous envelope, called the **hyaloid membrane.** This membrane is in contact with the retina, except anteriorly, in which latter situation it presents an excavation called the *fossa patellaris*, into which the posterior surface of the crystalline lens is received.

Towards its circumference the vitreous body is laminated, the laminæ being arranged concentrically. Laminæ are also said to

radiate from its antero-posterior axis towards the circumference. Scattered throughout the vitreous body there are some amœboid corpuscles, and it is traversed from behind forwards by a minute passage called the **hyaloid canal,** or **canal of Stilling (canal of Cloquet).** This canal extends from the centre of the optic disc to the posterior wall of the capsule of the lens, and posteriorly it communicates with the lymph-spaces of the optic nerve. In the fœtus the canal transmits a branch of the arteria centralis retinæ, called the *hyaloid artery,* which supplies the capsule of the lens.

No vessels enter the vitreous body, its nutrition being derived from the vessels of the retina and ciliary processes.

Zonula of Zinn.—The zonula of Zinn, or **zonula ciliaris,** is the thickened portion of the hyaloid membrane which is situated in front of the ora serrata of the retina. From this point it extends inwards behind the ciliary processes towards the periphery of the crystalline lens. Behind the ciliary processes it presents radial folds with intervening depressions. The depressions receive the ciliary processes, and the radial folds are separated from the intervals between the ciliary processes by lymph-spaces, which communicate with the posterior chamber of the eye.

Suspensory Ligament of the Lens, and Canal of Petit.—The zonula of Zinn, as it approaches the periphery of the lens, divides into three layers, posterior, middle, and anterior. The *posterior layer* lines the fossa patellaris on the anterior aspect of the hyaloid membrane. The *middle layer* consists of a few scattered fibres which pass to the equator of the lens. The *anterior layer* is the thickest, and constitutes the **suspensory ligament of the lens,** which is attached to the anterior wall of the capsule of the lens not far from the equator. When the radiating fibres of the ciliary muscle contract the suspensory ligament is relaxed, and the convexity of the anterior surface of the lens is increased.

Behind the suspensory ligament of the lens there is a sacculated lymph-space, called the **canal of Petit,** which surrounds the equator of the lens.

Development of the Eye.—The various parts of the eye are developed from different sources. The optic nerve and retina are developed from the brain. The sclerotic, cornea, choroid, iris, and vitreous body are of mesoblastic origin, and the crystalline lens is of epiblastic origin.

1. The earliest stage consists in the formation of a hollow protrusion from the anterior and lateral part of the anterior primary cerebral vesicle, which protrusion is called the **primary optic vesicle.** This vesicle grows outwards towards the external epiblast and undergoes enlargement, the narrow part of it which is connected with the anterior cerebral vesicle being known as the **optic stalk.** The primary optic vesicle and the optic stalk are at first hollow, and both communicate with the anterior cerebral vesicle.

2. An invagination of the primary optic vesicle and front part of the optic stalk next takes place, this invagination being called the **optic cup,** or **secondary optic vesicle.** This leads to almost entire disappearance of the cavity of the primary optic vesicle, and the wall of the optic cup is obviously formed of two layers, outer and inner. The *outer layer* gives rise to the **pigmentary stratum** of the retina, and from the *inner layer* all the other strata of the retina, seven in number, are developed.

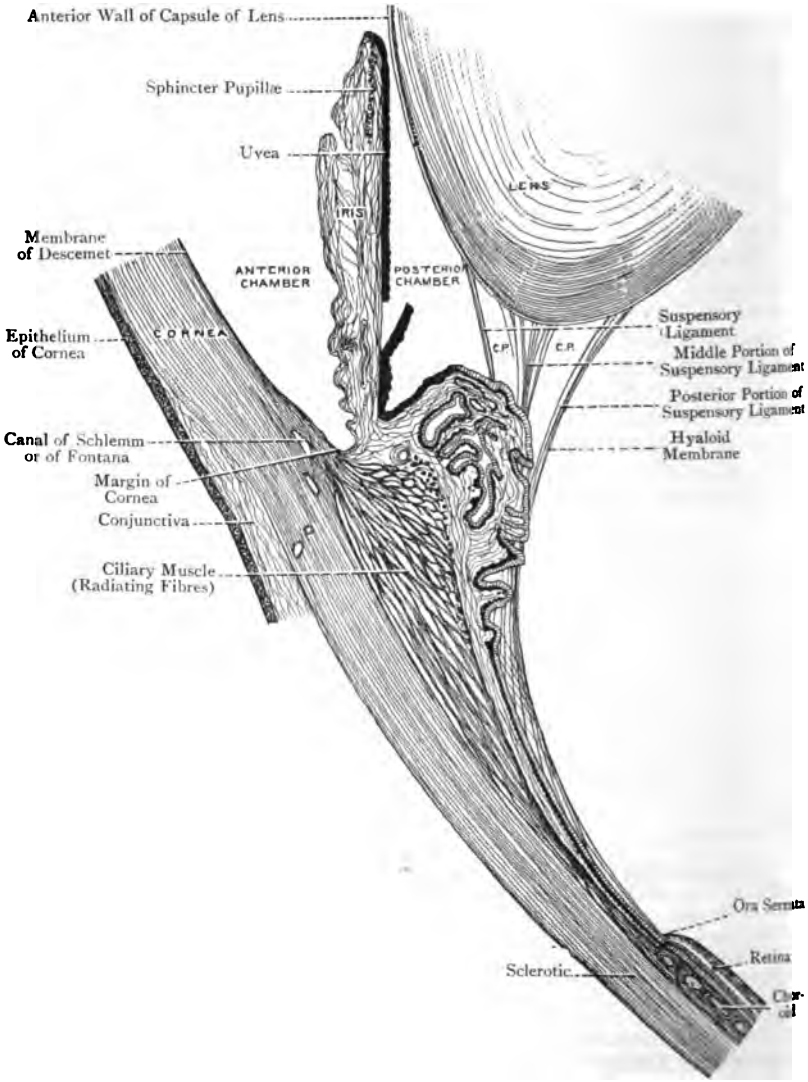


FIG. 616.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE (MAGNIFIED 16 × 1) (FUCHS).

C.P., C.P., Canal of Petit.

3. Simultaneously with the formation of the optic cup an invagination of the epiblast takes place opposite the invagination of the primary optic vesicle which forms the optic cup. This epiblastic invagination becomes constricted at its orifice, and ultimately closed. It is then completely separated from the external epiblast, of which it was originally an invagination, and it now forms a closed sac, called the **lens vesicle,** within the optic cup. This sac is lined with epithelium, and is embedded in mesoblast which has entered the optic cup through a cleft in its lower boundary, which cleft becomes subsequently closed. The cells lining the posterior half of the epiblastic sac become elongated in a forward direction, obliterating the cavity of the sac, and coming into contact with the cells which line the anterior half. By this process of cell-elongation the fibres of the **crystalline lens** are formed. The cells lining the anterior half of the epiblastic sac do not become elongated (except at the periphery of the crystalline lens), and these cells give rise to the permanent epithelium which covers the anterior surface of the lens. The capsule of the crystalline lens may be of mesoblastic origin, or it may be developed from the cells of the lens.

The mesoblast in the optic cup, in which the lens vesicle is embedded, gives rise to the **sclerotic, cornea, choroid, iris,** and **vitreous body.**

The **optic stalks,** which latterly are connected with the thalamencephalon or diencephalon, become solid ; and form the **optic nerves.**

THE EAR

THE organ of hearing is divided into three parts, namely, the external ear, the middle ear, and the internal ear.

External Ear.

The external ear consists of the auricle or pinna, and the meatus auditorius externus. The auricle has been already described (see p. 1114).

The **meatus auditorius externus** extends from the concha to the membrana tympani. Its direction is at first forwards and slightly upwards, then inwards, and finally forwards and downwards. Its length is rather more than 1 inch. Over about its inner two-thirds the canal is osseous, and is lodged within the petrous part of the temporal tone. The floor of the osseous part presents a slight elevation at the centre, where the passage is narrower than elsewhere, this narrow part being termed the **isthmus.** The outer third of the canal is formed by the rolled portion of the cartilage of the auricle, which is attached by fibrous tissue to the external auditory process of the temporal bone. This cartilage, as stated, presents a deficiency at the anterior and upper part, which is occupied by a fibrous membrane. It also presents a variable number of transverse clefts, called the *fissures of Santorini*, which are filled with fibrous tissue. The orifice of the meatus is oval, its long axis being vertical. Its deep extremity is nearly circular, and is closed by the membrana tympani, which is set obliquely, being inclined downwards, forwards, and towards the median line. It forms an acute angle with the lower wall, and an obtuse angle with the upper wall. In this manner the lower wall or floor is longer than the upper wall or roof, the anterior wall being also longer than the posterior wall.

The meatus is lined with skin, which is continuous with that of the auricle. In the osseous part of the canal the skin is very thin, and is provided with vascular papillæ, but is destitute of glands and hairs. It is reflected over the outer surface of the membrana tympani, of which it forms the outer layer. In the cartilaginous part of the canal the skin is thicker, and is provided with hairs, connected with the follicles of which are sebaceous glands. In

addition to these sebaceous glands, there are convoluted tubular glands, similar in structure to sweat-glands, and called the **ceruminous glands,** which secrete the ear-wax.

Blood-supply.—The **arteries** are derived from the posterior auricular of the external carotid, the deep auricular of the first part of the internal maxillary, and the anterior auricular branches of the superficial temporal. The **veins** follow the course of the arteries.

Lymphatics.—These pass to the mastoid glands and to the parotid lymphatic glands.

Nerves.—(1) The auriculo-temporal nerve furnishes two branches to the meatus, upper and lower, which enter it by passing between

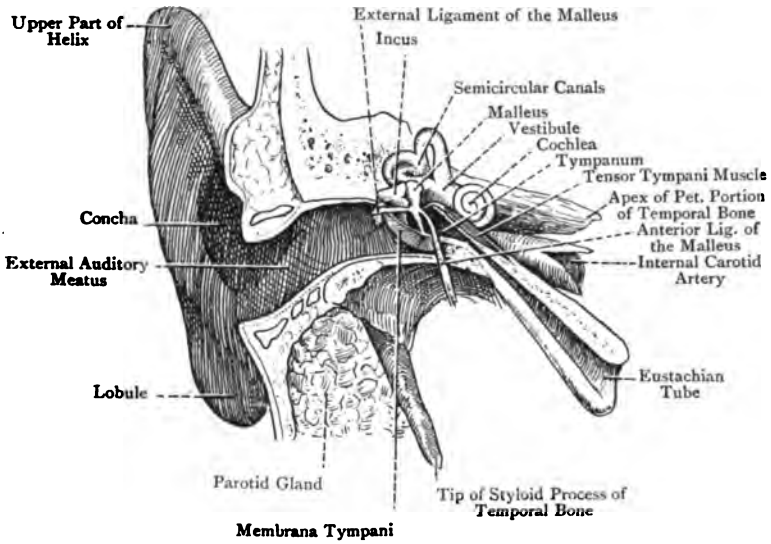


FIG. 617.—GENERAL VIEW OF THE RIGHT ORGAN OF HEARING (AFTER HIRSCHFELD AND LEVEILLÉ).

(The External Ear and Middle Ear are seen in section).

the cartilaginous and osseous walls. The upper branch furnishes twigs to the skin over the upper part of the membrana tympani. (2) The auricular branch (Arnold's nerve) of the pneumogastric supplies the skin of the osseous part of the canal over its lower and back part, and also the skin over the lower part of the membrana tympani.

Early Condition of the Meatus.—At birth the osseous part of the canal is represented merely by the *tympanic annulus* and a small portion of the squamous part of the temporal bone. It is connected by fibrous tissue to the cartilaginous framework of the auricle, and within this fibrous tissue the osseous canal becomes formed by an outgrowth from the tympanic annulus.

Middle Ear.

The middle ear, or **tympanum,** is an irregular space within the petrous part of the temporal bone, which lies between the membrana tympani externally and the outer osseous wall of the internal ear or labyrinth internally. Its transverse measurement, opposite the centre of the membrana tympani, is about $\frac{1}{12}$ inch; from above downwards it measures about $\frac{1}{2}$ inch; and from before backwards rather more than $\frac{1}{2}$ inch. The cavity presents six walls, namely, outer, inner, roof, floor, anterior, and posterior.

The **outer wall** is formed (1) chiefly by the membrana tympani, which has the handle of the malleus fixed to it, and (2) slightly by the tympanic annulus, within the circumference of which there is a groove, called the *sulcus tympanicus*, in which the membrana tympani is set. The tympanic annulus and sulcus are interrupted superiorly by a notch, called the **notch of Rivini.** In front of the tympanic annulus is the open, inner extremity of the **fissure of Glaser,** which lodges the processus gracilis of the malleus, and transmits the tympanic branch of the internal maxillary artery. At the inner end of the fissure of Glaser is the opening of the *iter chordæ anterius*, or **canal of Huguier,** by which the chorda tympani nerve leaves the tympanum.

The **inner wall** separates the tympanum from the internal ear or labyrinth. It is very irregular, and presents the following parts:

1. The fenestra ovalis.
2. Projection formed by part of the aqueduct of Fallopius.
3. The promontory.
4. The fenestra rotunda.
5. The sinus tympani.

The **fenestra ovalis** is situated in a depression, called the **fossula ovalis,** at the upper part of the inner wall, and it leads into the cavity of the vestibule. It is irregularly oval, and is elongated from before backwards. It is occupied by the footpiece of the stapes, and the annular ligament which connects the circumference of the footpiece to the margin of the opening, the margin being covered by cartilage.

The **projection formed by part of the aqueduct of Fallopius** is situated above the fenestra ovalis. The aqueduct, which contains the facial nerve, is here directed backwards.

The **promontory** (*tuber cochleæ*) is situated below the fenestra ovalis, between it and the fenestra rotunda, and slightly anterior to both. It is a rounded prominence which is produced by the first turn of the cochlea, and it presents grooves for the nerves of the tympanic plexus.

The **fenestra rotunda** is situated in a funnel-shaped depression, called the **fossula rotunda,** below and behind the promontory. It leads into the scala tympani of the cochlea, and in the recent state is closed by the secondary membrane of the tympanum.

The **sinus tympani** is a depression situated behind the promontory, and between the fossula ovalis and fossula rotunda.

The **roof** of the tympanum is formed by a thin plate of bone,

called the *tegmen tympani*, which forms part of the superior surface of the petrous part of the temporal bone.

The **floor** is formed by a thin plate of bone which separates the tympanum from the jugular fossa.

The **anterior wall** is narrow, owing to the descent of the roof, and the inclination towards each other of the outer and inner walls. It presents the orifices of two canals, the upper of which lodges the tensor tympani muscle, whilst the lower is the osseous part of the Eustachian tube. The two orifices are separated by the margin of the *processus cochleariformis*.

The **posterior wall** is formed by the anterior or tympanic surface

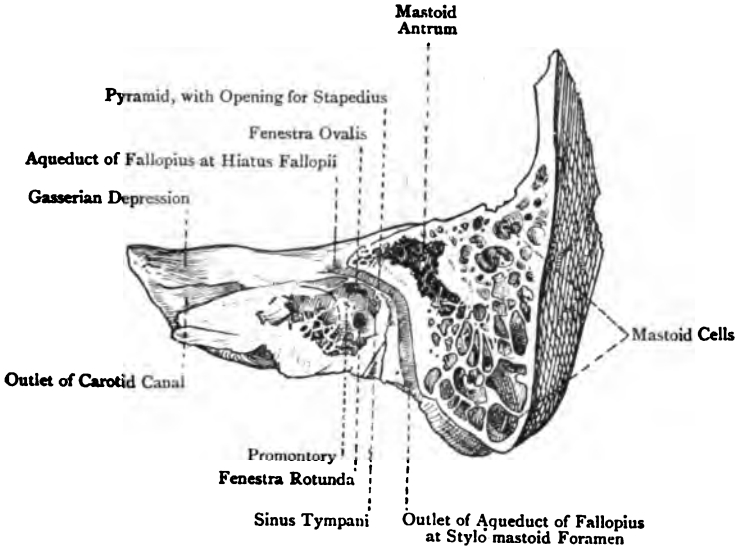


FIG. 618.—SECTION THROUGH THE PETROUS AND MASTOID PORTIONS OF THE TEMPORAL BONE, SHOWING THE TYMPANUM AND MASTOID CELLS.

of the petrous part of the temporal bone. It presents, from above downwards, the following parts: (1) the opening of the mastoid antrum, which communicates with the attic of the tympanum, or epitympanic recess; (2) a depression called the **fossa incudis,** which receives the short process of the incus; (3) a small conical projection, called the **pyramid,** the summit of which presents an opening for the passage of the tendon of the stapedius muscle; (posteriorly the canal within the pyramid, which contains the stapedius muscle, passes downwards in the posterior wall of the tympanum, and communicates with the descending part of the aqueduct of Fallopius, which contains the facial nerve, thus explaining how the branch of that nerve to the stapedius reaches the

muscle); and (4) the **iter chordæ posterius,** for the passage of the chorda tympani nerve.

Membrana Tympani.—This is the membrane which closes the inner extremity of the meatus auditorius externus. It is situated on the outer wall of the tympanum, of which it forms the chief part, and it is set, for the most part, in the sulcus tympanicus, which marks the inner surface of the tympanic annulus. Superiorly, however, where the annulus is deficient, the membrane is attached to the notch of Rivini. This part of it is thinner and looser than the rest, and is called the **membrana flaccida,** or **Shrapnell's membrane.** The attachment of the membrana tympani to the sulcus tympanicus is effected by means of a thickened band of fibres, disposed in the form of a ring, called the *annulus fibrosus.* This annulus passes

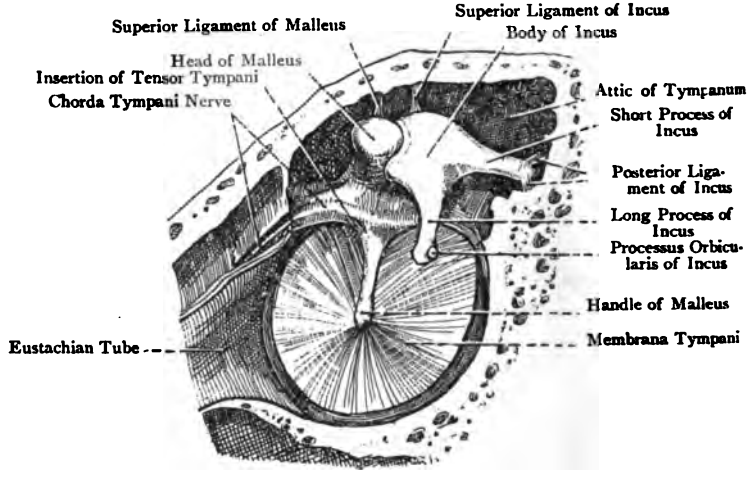


FIG. 619.—THE RIGHT MEMBRANA TYMPANI, MALLEUS, AND INCUS (INTERNAL, POSTERIOR, AND SUPERIOR VIEW) (SPALTEHOLZ).

from the extremities of the notch of Rivini to the short process of the malleus in the form of two bands, which are known as the **anterior** and **external malleolar ligaments,** and which form the lower boundary of the membrana flaccida. Opposite the notch of Rivini these annular fibres separate the membrana flaccida from the rest of the membrana tympani. The membrane is set obliquely in the sulcus tympanicus, so that its lower part forms an acute angle with the floor of the meatus auditorius externus, and its upper part an obtuse angle with the roof of the passage.

The membrana tympani is somewhat oval. In the vertical direction it measures about 10 mm., and horizontally from 8 to 9 mm. The handle of the malleus lies between the mucous and fibrous layers of the membrane, and descends to a point a little below its centre, where it ends in a small knob, from which the radi-

ating fibres of the membrane proceed. This knob is firmly attached, and, being directed inwards, the membrane is consequently drawn inwards at that point, and its outer surface presents a slight conical depression, the deepest part of which is called the **umbo.**

Structure.—The membrana tympani consists of three layers—external, middle, and internal.

The **external** or **cutaneous layer** is very thin, and is derived from the skin of the meatus auditorius externus. It contains no glands, is freely provided with bloodvessels and nerves, and is covered by stratified squamous epithelium.

The **middle** or **fibrous layer** forms the proper substance of the membrane, and consists of fibrous tissue. The fibres are arranged in two sets—radial and circular. The *radial fibres* lie beneath the cutaneous layer, and radiate from the handle of the malleus to the annulus fibrosus. The *circular fibres* are situated within the radial fibres, and are most numerous towards the circumference of the membrane. Both sets of fibres are absent from the membrana flaccida.

The **internal** or **mucous layer** is continuous with the mucous membrane of the tympanum, and is covered by a single layer of squamous epithelium.

The **membrana flaccida,** or **Shrapnell's membrane,** is composed of two layers—cutaneous and mucous, there being no fibrous layer. These two layers are united by connective tissue, which is very loosely arranged, and this renders the membrane flaccid. This part is very liable to perforation.

Cone of Light.—Extending from the knob, in which the handle of the malleus terminates, downwards and inwards to the antero-inferior margin of the membrana tympani there is seen a specially bright reflection, triangular in outline, with the apex towards the umbo. This is called the **cone of light.**

Arterial Supply of the Membrana Tympani.—(1) Deep auricular branch of the internal maxillary artery. This vessel, which passes through the anterior wall of the meatus auditorius externus, supplies the cutaneous layer. It descends from the skin of the roof of the meatus along the course of the handle of the malleus to the umbo, where it divides into branches which radiate towards the circumference of the membrane. (2) The stylo-mastoid branch of the posterior auricular, and (3) the tympanic branch of the internal maxillary. The former artery enters the tympanum from the aqueduct of Fallopius, and the latter through the fissure of Glaser. Branches from them supply the mucous layer, and form an anastomotic ring around the circumference of the membrane. The fibrous layer receives its arterial supply from the vessels of the cutaneous and mucous layers.

The **veins** pass to the external jugular and internal jugular veins.

Nerve-supply.—The nerves are derived from (1) the auriculo-temporal of the inferior maxillary, (2) the auricular branch (Arnold's

nerve) of the pneumogastric, and (3) branches from the tympanic plexus.

Secondary Membrane of the Tympanum.—This membrane closes the fenestra rotunda on the inner wall of the tympanum, and separates the tympanic cavity from the scala tympani of the cochlea. It is concave towards the tympanum, and, like the membrana tympani, it consists of three layers. The **external layer** is formed by the tympanic mucous membrane; the **middle layer** is fibrous; and the **internal layer** is formed by the lining membrane of the cochlea.

The mastoid antrum and mastoid air-cells will be found described in connection with the temporal bone, and a description of the Eustachian tube will be found on p. 1190.

Ossicles of the Tympanum.

The tympanum contains three small bones, arranged in the form of a chain which extends from the membrana tympani to the fenestra ovalis. The bones are the malleus, the incus, and the stapes. The malleus is related to the membrana tympani, the stapes to the fenestra ovalis, and the incus occupies an intermediate position between these two.

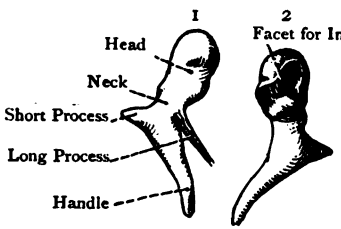


FIG. 620.—THE MALLEUS.
1, Anterior View; 2, Posterior View.

The **malleus** is so named from its resemblance to a hammer. It is composed of a head, neck, handle, and two processes, namely, long and short. The **head** is the upper, enlarged, rounded end. Posteriorly it presents a saddle-shaped facet, directed obliquely downwards and inwards, for articulation with the incus in a synovial joint. The **neck** is the constricted part below the head. The **handle** (*manubrium*) is directed downwards, inwards, and backwards from the neck; it is compressed from before backwards, and slightly curved, and it terminates in a slight knob. It lies between the fibrous and mucous layers of the membrana tympani, descending to a point a little below the centre of the membrane. It is firmly attached to the fibrous layer by its periosteum. The tensor tympani muscle is inserted into its inner part, close to its root. The **long process** (*processus gracilis*), which is slender, springs from the front of the neck, and is directed forwards and downwards to the fissure of Glaser, where it is embedded in fibres which form part of the anterior ligament of the malleus, and connect it to the margins of the fissure. The long process is in the adult for the most part replaced by fibrous tissue, except close to the neck of the malleus. In early life it is continuous with Meckel's cartilage. The **short process** (*processus brevis*) is situated immediately below the long process. It is directed outwards to the upper part of the membrana

tympani, with which it is connected by the annulus fibrosus. It is also connected with the extremities of the notch of Rivini by those bands of the annulus fibrosus which are known as the anterior and posterior malleolar ligaments.

The **incus** has been so named from its resemblance to an anvil. It consists of a body and two processes—short and long. The **body** is thick, somewhat four-sided, and laterally compressed. Anteriorly it presents a saddle-shaped articular surface for the head of the malleus, with which it forms a synovial joint. The **short process** is directed backwards, is tipped with cartilage, and articulates with the fossa incudis on the posterior wall of the tympanum. The **long process** is directed downwards and inwards, behind and parallel to the handle of the malleus. Its lower extremity is bent inwards, and becomes narrowed into a neck, upon which is placed a disc-like knob of bone, called the **processus lenticularis seu orbicularis,** which is covered by cartilage for articulation with the head of the stapes. In early life, and up to the sixth month of intra-uterine life, this process forms a separate ossicle, called the *os orbiculare*.

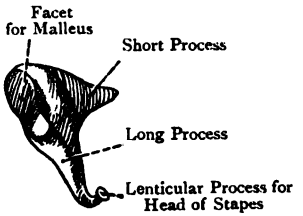


FIG. 621. — THE INCUS.
(Postero-internal View).

The **stapes** is so named from its resemblance to a stirrup. It consists of a head, neck, two crura, and a foot-piece or base. The **head** is directed outwards, is concave and covered by cartilage, and articulates with the processus lenticularis of the incus. The **neck** is the constricted part which lies immediately internal to the head. Posteriorly it gives insertion to the stapedius muscle. The **crura** are anterior and posterior respectively, and spring from the neck. They diverge as they pass inwards, and are attached to the foot-piece near its extremities. The *anterior* crus is straighter and shorter than the *posterior*. The **foot-piece** or **base** is somewhat oval, is directed inwards, and occupies the fenestra ovalis, which it almost completely fills; its circumference is covered by cartilage, being attached to the margins of the fenestra by annular ligamentous fibres. The arch formed by the crura and foot-piece is occupied by a delicate membrane, which is attached to a slight groove on the inner aspect of the arch.

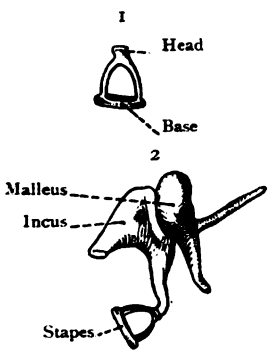


FIG. 622.—(1) THE STAPES, AND (2) TYMPANIC OSSICLES IN POSITION.

Development of the Tympanic Ossicles.—The **malleus** and **incus** are usually regarded as being developed from the proximal end of Meckel's cartilage,

which forms the cartilaginous bar of the first or mandibular arch. According to some authorities, however, the **incus** is developed from the hyoid bar, and according to others both the malleus and incus are of hyo-mandibular origin. The stapes is usually regarded as being developed from cartilage in the vicinity of the fenestra ovalis which surrounds the stapedial artery of early life.

Ligaments of the Ossicles.—The synovial joints between the malleus and incus, and between the incus and stapes are provided with thin capsular ligaments. The ligaments which connect the ossicles to the walls of the tympanic cavity are five in number, three of them belonging to the malleus, one to the incus, and one to the stapes.

The **ligaments of the malleus** are anterior, external, and superior. The **anterior ligament** is arranged in two parts, as follows : (1) the **band of Meckel** (formerly known as the laxator tympani muscle), which extends from the root of the long process to the fissure of Glaser, through which it passes to be attached to the spine of the sphenoid bone ; and (2) the so-called **anterior malleolar ligament,** which extends from the short process to the anterior extremity of the notch of Rivini. The **external ligament** extends from the short process to the posterior extremity of the notch of Rivini. The **superior ligament** extends from the head of the malleus to the roof of the attic or epitympanic recess.

The **ligament of the incus** connects the short process, near its posterior extremity, to the fossa incudis.

The **annular ligament of the stapes** connects the circumference of the foot-piece, which is covered by cartilage, to the margin of the fenestra ovalis, which is also covered by cartilage.

Muscles of the Tympanum.—These are two in number, namely, the tensor tympani and the stapedius.

Tensor Tympani—*Origin.*—(1) The cartilaginous part of the Eustachian tube, superiorly ; (2) the adjacent part of the great wing of the sphenoid ; and (3) the wall of the osseous canal through which the muscle passes.

Insertion.—The inner aspect of the handle of the malleus, close to its root.

Nerve-supply.—A branch from the otic ganglion, and, through it, from the internal pterygoid branch of the inferior maxillary division of the fifth cranial nerve.

The muscle consists of a fleshy belly, about ½ inch long, and a delicate tendon. In passing backwards to the tympanum it lies in a canal, the entrance to which is situated within the petro-squamous angle of the temporal bone. The canal is placed above the osseous part of the Eustachian tube, from which it is separated by the *processus cochleariformis.* On entering the tympanum the tendon of the muscle bends sharply over the edge of the processus cochleariformis, and then passes outwards to reach its insertion. The tendon forms very nearly a right angle with the fleshy belly.

Action.—To render tense the membrana tympani by drawing

inwards the handle of the malleus, and, along with it, the membrane.

Stapedius—*Origin.*—The wall of the canal within the pyramid, and of the continuation of this canal in front of the descending part of the aqueduct of Fallopius.

The tendon emerges from the canal within the pyramid through a small orifice on the apex.

Insertion.—The posterior aspect of the neck of the stapes.

Nerve-supply.—The facial nerve.

Action.—To draw the head of the stapes backwards. The result is that the front part of the foot-piece of the stapes is tilted away from the vestibule, and its back part is pressed inwards towards the vestibule.

Movements of the Ossicles.—The malleus and incus move simultaneously, the movement being one of rotation round an axis extending from the tip of the long process of the malleus to the tip of the short process of the incus. During the action of the tensor tympani muscle, when the handle of the malleus and the membrana tympani are drawn inwards, the long process of the incus is pushed inwards, and the stapes is thereby pressed inwards. The result is that the foot-piece of the stapes presses upon the perilymph of the labyrinth, and the secondary membrane of the tympanum is pressed outwards. Probably the stapedius tends to prevent undue pressure upon the perilymph of the labyrinth during strong contraction of the tensor tympani by the tilting action already ascribed to it.

Mucous Membrane of the Tympanum.—The tympanic mucous membrane is continuous anteriorly with that of the naso-pharynx through the Eustachian tube. Posteriorly it is prolonged into the mastoid antrum, and thence into the mastoid cells. It forms the internal layer of the membrana tympani, and the external layer of the secondary membrane of the tympanum. It also furnishes sheaths for the tendons of the tensor tympani and stapedius muscles, and for the chorda tympani nerve. Two folds extend downwards from the roof of the attic or epitympanic recess, one in front of, and the other behind, the superior ligament of the malleus. The former is connected with the head of the malleus, and the latter (sometimes described as the superior ligament of the incus) with the incus.

Attic or Epitympanic Recess, and its Pouches.—The part of the tympanic cavity which lies above the level of the upper margin of the membrana tympani is called the **attic** or **epitympanic recess,** as distinguished from the *atrium* or *tympanum proper.* It contains the head and neck of the malleus, and the body and short process of the incus. These divide it incompletely into two compartments—outer and inner. The **outer attic** is subdivided into two pouches—superior and inferior. The **superior pouch** is partially separated from the **inner attic** by the two mucous folds which have been already referred to as descending from the roof

of the attic in front of and behind the superior ligament of the malleus. The **inferior pouch** of the outer attic is known as the *pouch of Prussak*. It is bounded externally by the membrana flaccida, superiorly by the external ligament of the malleus, which partially separates it from the superior pouch, and inferiorly by the short process of the malleus. The pouch communicates posteriorly with the tympanic cavity by an opening which is situated a little above the level of the bottom of the pouch. If fluid therefore should accumulate in Prussak's pouch, it may readily lead to perforation of the membrana flaccida or Shrapnell's membrane.

Two other pouches are present, namely, the **anterior** and **posterior pouches of Troltsch.** These lie one in front of, and the other behind, the handle of the malleus, and are produced by the fold of mucous membrane which invests the chorda tympani nerve.

The tympanic mucous membrane is covered, for the most part, by columnar ciliated epithelium, except over the ossicles and membrana tympani, where the epithelium consists of a single layer of squamous, non-ciliated cells.

Arteries of the Tympanum.—The principal arteries are two in number, namely, (1) the tympanic branch of the internal maxillary, and (2) the stylo-mastoid branch of the posterior auricular. The **tympanic artery** enters through the fissure of Glaser, and supplies the membrana tympani and front part of the tympanum. The **stylo-mastoid artery** enters the aqueduct of Fallopius through the stylo-mastoid foramen, and passes from the descending part of the aqueduct into the tympanum. It supplies the back part of the cavity and the mastoid cells, and it forms, with the tympanic artery, a ring round the circumference of the membrana tympani.

In addition to the foregoing two arteries, the following three arteries enter the tympanic cavity: (1) the petrosal branch of the middle meningeal, which enters from the aqueduct of Fallopius, into which it passes through the hiatus Fallopii; (2) the tympanic branch of the ascending pharyngeal, which accompanies Jacobson's nerve through the tympanic canaliculus; and (3) the tympanic branch of the internal carotid, which enters by a minute foramen on the posterior wall of the ascending part of the carotid canal, in company with a sympathetic twig from the carotid plexus.

The **veins** of the tympanum pass to the pterygoid plexus, the superior petrosal sinus, the internal jugular vein, and the pharyngeal plexus.

Nerves of the Tympanum—1. **Tympanic Plexus.**—This plexus is situated on the inner wall of the tympanic cavity, more particularly over the promontory. It is formed by (*a*) the tympanic branch (Jacobson's nerve) of the petrous ganglion of the glosso-pharyngeal, and (*b*) the carotico-tympanic branch of the carotid plexus of the sympathetic.

Branches.—These are distributed to the mucous membrane of the tympanum, Eustachian tube, and mastoid cells. Besides these, there are two named branches, called the small superficial petrosal and the small deep petrosal. The **small superficial petrosal nerve** is to be regarded as the continuation of Jacobson's nerve. After issuing from the tympanic plexus it leaves the tympanum at the upper part of the anterior wall, and traverses a small canal in the petrous part of the temporal bone, passing beneath the upper portion of the canal which lodges the tensor tympani muscle. Whilst in this canal it is joined by a small branch from the geniculate ganglion of the facial nerve, and it emerges from the canal through the accessory hiatus on the superior surface of the pars petrosa. It then passes forwards and inwards beneath the dura mater, and leaves the cranial cavity through the canaliculus innominatus, or through the fissure between the pars petrosa and the great wing of the sphenoid, or through the foramen ovale. Having entered

the zygomatic fossa, it joins the otic ganglion, to which it conducts glossopharyngeal fibres.

The **small deep petrosal nerve** passes forwards through a minute canal within the processus cochleariformis to the upper aspect of the foramen lacerum medium, where it joins the carotid plexus of the sympathetic and the great deep petrosal, or, it may be, the great superficial petrosal, nerve. In this manner some of its fibres pass in the Vidian nerve to Meckel's ganglion.

2. **Chorda Tympani Nerve.**—This nerve arises from the facial nerve in the lower portion of the descending part of the aqueduct of Fallopius. Having ascended for a little in the aqueduct, it leaves it by passing forwards through a minute canal, called the *iter chordæ posterius*, which opens on the posterior wall of the tympanum, below the level of the pyramid. The nerve, invested by a fold of mucous membrane, now passes forwards internal to the membrana tympani, and over the upper part of the handle of the malleus. It then leaves the tympanic cavity through a passage situated at the inner end of the fissure of Glaser, called the *iter chordæ anterius*, or **canal of Huguier,** after which it joins the lingual nerve.

Internal Ear.

The internal ear is the essential part of the organ of hearing, and is known as the **labyrinth** from its remarkable complexity. It consists of two parts, namely, the osseous labyrinth and the membranous labyrinth.

Osseous Labyrinth.

The osseous labyrinth is a cavity situated within the petrous part of the temporal bone, and it is divided into three parts, namely, the **vestibule**, the **semicircular canals**, and the **cochlea.** These divisions are lined with a delicate periosteum, between which and the contained membranous labyrinth there is a clear fluid, called the **perilymph.**

Vestibule.—The vestibule is the central division of the osseous labyrinth. The semicircular canals lie behind it, and the cochlea is situated in front of it. The *outer wall* presents the fenestra ovalis, which is occupied by the foot-piece of the stapes and its annular ligament. The *inner wall* presents anteriorly a depression called the **fovea spherica**, which corresponds to the lamina cribrosa at the deep end of the meatus auditorius internus. It is pierced by apertures for the passage of filaments of the auditory nerve to the saccule. Behind and above the fovea spherica there is a ridge, called the **crista vestibuli,** which lies obliquely. Posteriorly it bifurcates, and between its two divisions there is a small depression, called the **recessus cochlearis,** which presents a few openings for the passage of nerve filaments to the canalis cochleæ. Anteriorly it becomes somewhat triangular, and forms the **pyramid**, which is pierced by foramina for the passage of nerves to the utricle.

The roof of the vestibule, behind and above the crista vestibuli, presents an oval depression, called the **fovea elliptica,** which encroaches on the inner wall and lodges the **recessus utriculi.** It is pierced by foramina for the passage of the nerves to the ampullæ

of the superior and external semicircular canals. Below the fovea elliptica is the opening of the aqueductus vestibuli, which leads to the posterior surface of the petrous part of the temporal bone, about ¼ inch external to the orifice of the meatus auditorius internus. It transmits the ductus endolymphaticus and a minute vein.

Anteriorly the vestibule communicates with the scala vestibuli

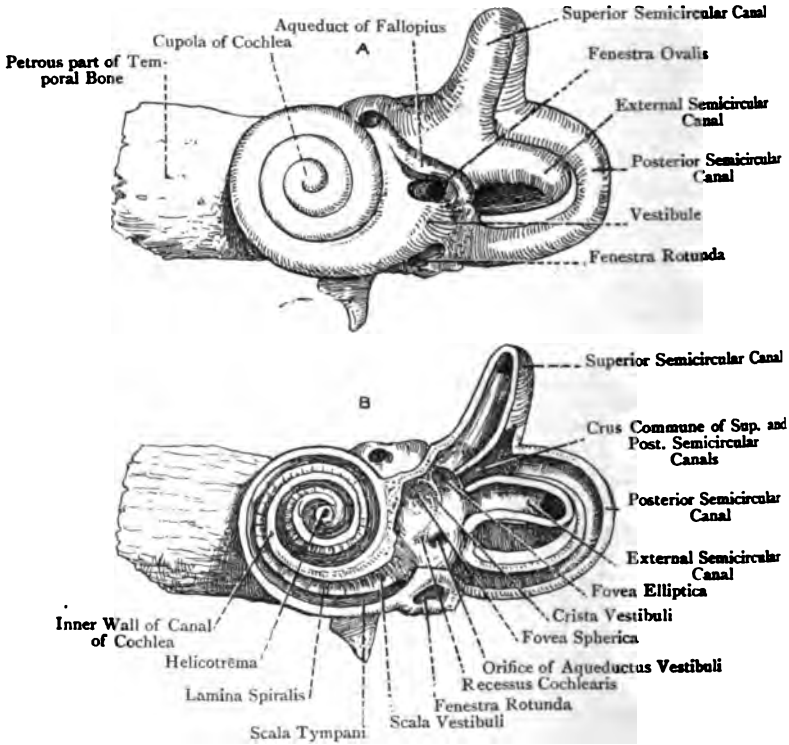


FIG. 623.—THE OSSEOUS LABYRINTH OF THE LEFT SIDE (EXTERNAL VIEW).

A, Entire; B, Opened (Hirschfeld and Leveillé. B, Modified).

of the cochlea, and posteriorly it presents the five openings of the semicircular canals.

Semicircular Canals.—The **osseous semicircular canals** are situated behind the vestibule. They are three in number—superior, posterior, and external—and they open into the vestibule by five circular apertures, the contiguous ends of the superior and posterior canals having a common orifice. Each canal forms about two-thirds of a circle, and each presents at one end an enlargement,

called the **ampulla**. The **superior semicircular canal** occupies a vertical position, and lies transversely as regards the long axis of the petrous part of the temporal bone, giving rise to the *eminentia arcuata* on its superior surface. Its ampullary end (antero-external) opens independently into the upper part of the vestibule, above the ampullary orifice of the external canal. Its non-ampullary end unites with the non-ampullary end of the posterior canal, and the two open by a common orifice into the vestibule. The **posterior semicircular canal** arches backwards towards the posterior surface of the pars petrosa, with which it is almost parallel, and, like the superior, it occupies a vertical position. Its ampullary end (inferior) opens independently into the lower and back part of the vestibule, and its non-ampullary end, as just stated, joins that of the superior canal. The **external semicircular canal** arches outwards, and occupies a horizontal position. Its extremities are independent of those of the other two canals, and they open by separate apertures into the upper and back part of the vestibule. Its ampullary end is external.

Cochlea.—The osseous cochlea is situated in front of the vestibule. It consists of a tube coiled spirally upon itself, like a snail's shell, and is of conical outline. Its base is opposite the lamina cribrosa at the deep end of the meatus auditorius internus ; and its apex, known as the **cupola,** is directed outwards and slightly forwards towards the canal which contains the tensor tympani muscle. Its length from base to apex is about $\frac{1}{5}$ inch. It consists of the following parts : (1) a central pillar, called the **modiolus** ; (2) a canal, winding spirally round the modiolus ; and (3) an osseous plate, called the **lamina spiralis,** which projects from the modiolus into the canal throughout its windings.

The **modiolus** is the central pillar of the cochlea. It commences at the cochlear area of the lamina cribrosa, and extends almost to the apex or cupola. It contains canals, which transmit branches of the cochlear division of the auditory nerve and of the internal auditory artery to the lamina spiralis. At the attached margin of the lamina spiralis these canals become united and form the **spiral canal** of the modiolus, which lodges the spiral ganglion, or ganglion of Corti, and communicates freely with the lamina spiralis.

The *lamina cribrosa*, at the deep end of the meatus auditorius internus, will be found described on p. 73.

The **canal of the cochlea** winds spirally round the modiolus, which forms its inner wall, and it describes two and three-quarter turns. At the cupola it terminates in a blind extremity. Its length is about 30 mm. and its breadth at the base about 2 mm. The first turn of the canal gives rise to the promontory on the inner wall of the tympanum.

The **lamina spiralis** is a shelf of bone which projects from the modiolus into the canal of the cochlea throughout its windings, and it divides the canal incompletely into two passages—an upper or scala vestibuli, and a lower or scala tympani. The lamina

spiralis extends across the canal towards its outer wall for about half its width, and in the recent state the remainder of the distance is completed by the basilar membrane. Close to the cupola the lamina spiralis ends in a hook-like process, called the *hamulus*. The spiral lamina consists of two plates of bone, between which there are canals for branches of the cochlear division of the auditory nerve and of the internal auditory artery. These canals open out from the spiral canal of the modiolus.

At the lower end of the scala tympani is the upper opening of the **aqueductus cochleæ,** which passes downwards and inwards to terminate on the posterior border of the petrous part of the temporal bone. It transmits a small vein to the inferior petrosal sinus, and

FIG. 624.—MEDIAN SECTION OF THE LEFT OSSEOUS COCHLEA OF MAN FROM APEX TO BASE (ARNOLD).

S.V. Scala Vestibuli — L.S.O. Lamina Spiralis Ossea
S.T. Scala Tympani — C.C. Central Canal of Modiolus
M.A.I. Meatus Auditorius Internus

establishes a communication between the scala tympani and the subarachnoid space.

Membranous Labyrinth.

The membranous labyrinth is situated within the osseous labyrinth, and its constituent parts receive the terminal branches of the auditory nerve. It is separated from the periosteal lining of the osseous labyrinth by the **perilymph,** and it contains the fluid known as the **endolymph.** In the case of the vestibule and the osseous semicircular canals the membranous labyrinth corresponds, more or less, with them ; but in the case of the osseous cochlea it forms part of the septum between the scala tympani and scala vestibuli, and contains a passage called the membranous canal of the cochlea.

Vestibular Part of the Membranous Labyrinth.—The vestibule

contains two membranous sacs, namely, the utricle and the saccule, which are in close contact, but do not communicate with each other directly.

The **utricle** is the larger of the two sacs, and into it the membranous semicircular canals open. It occupies the upper and back part of the vestibule, a portion of it, known as the **recessus utriculi,** lying in the fovea elliptica. In the vicinity of the crista vestibuli the wall of this recess receives fibres of the auditory nerve and is thickened, this portion of it being called the **macula acustica utriculi.** From the anterior and inner part of the utricle a minute canal, called the **ductus utriculi** (*ductus utriculo-sacccularis*), passes to join the ductus sacculi, and so form the ductus endolymphaticus.

The **saccule,** which is somewhat oval, lies in front of the utricle, and occupies the fovea spherica, where it is contiguous to the opening leading into the scala vestibuli of the cochlea. Through the openings of the fovea spherica it receives filaments of the auditory nerve, and this portion of the saccule being thickened, is known as the *macula acustica sacculi.* Inferiorly the saccule is connected with a small canal, called the **canalis** or **ductus reuniens of Hensen,** which opens into the canal of the cochlea, or ductus cochlearis, not far from its closed vestibular end. From the posterior part of the saccule a minute canal, called the **ductus sacculi,** passes off, which is soon joined by the **ductus utriculi,** and so the **ductus endolymphaticus** is formed. This latter duct traverses the aqueductus vestibuli, and, having reached the posterior surface of the petrous part of the temporal bone, it ends in a small blind dilatation, called the *sacculus endolymphaticus,* which lies beneath the dura mater. The saccule and utricle are thus indirectly connected by means of the ductus sacculus and ductus utriculus; and the saccule communicates with the ductus cochlearis by means of the canalis or ductus reuniens of Hensen.

Semicircular Canals.—The membranous semicircular canals correspond in outline to the osseous semicircular canals, within which they lie; they form about two-thirds of a circle; and each presents an **ampulla** at one extremity, which is situated within the ampulla of the osseous canal. They are elliptical in transverse section, and open into the utricle by five orifices, the non-ampullary ends of the superior and posterior canals being united, so that these two ends open by a common orifice. The *convex* wall of each canal is attached to the periosteal lining of the osseous canal, whilst the *concave* wall is practically free from the osseous wall, and is bathed by the perilymph.

Structure.—The walls of the utricle, saccule, and membranous semicircular canals consist of three layers, namely, (1) an outer or fibrous layer, which is vascular; (2) a middle layer, or membrana propria, which is translucent; and (3) an inner or epithelial layer. In each ampulla the middle layer, or **membrana propria,** projects into the cavity of the canal from the peripheral wall, this projecting

part being known as the *septum transversum*. It partially divides the interior of the ampulla into two compartments, and its free margin, which is covered by the auditory epithelium, is called the **crista acustica.** The **epithelial layer** consists of a single stratum of squamous cells, except in those regions to which the filaments of the auditory nerve are distributed. These regions are as follows: (1) the macula acustica utriculi; (2) the macula acustica sacculi; and (3) the crista acustica of each ampulla.

The **macula acustica utriculi** is the thickened part of the antero-inferior wall of the recessus utriculi, and is lined with auditory epithelium. The macula is covered by calcareous particles, called *otoliths* or *otoconia*, which consist of crystals of calcium carbonate. The **macula acustica sacculi** is the thickened part of the anterior wall of the saccule, and is also lined with auditory epithelium,

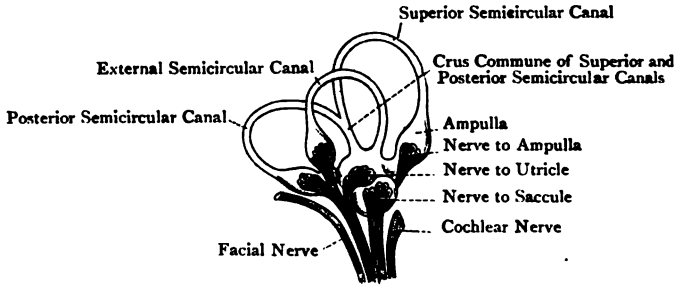


FIG. 625.—THE MEMBRANOUS SEMICIRCULAR CANALS, SHOWING THE DISTRIBUTION OF THE BRANCHES OF THE AUDITORY NERVE TO THEIR AMPULLÆ (BRESCHET).

covered by otoliths. The **crista acustica,** as stated, is the free margin of the septum transversum in each ampulla, and is covered by auditory epithelium.

The **auditory epithelium** is of the columnar variety, and consists of two kinds of cells, auditory and sustentacular. The **auditory cells** are nucleated, and each is provided at its free extremity with slender, tapering, hair-like filament, which projects into the cavity. These filaments are sometimes spoken of collectively as *auditory hairs*, and the cells are hence called **hair-cells.** Their deep extremities fall short of the membrana propria. The **sustentacular cells** lie between the hair-cells, and are elongated and nucleated. Their deep extremities are attached to the membrana propria, and their free extremities give rise to a kind of limiting membrane. The auditory nerve-fibres pierce the membrana propria, and, having lost their medullary sheaths, the axons terminate in arborizations around the deep ends of the auditory or hair cells.

Membranous Cochlea.—The membranous cochlea is situated within the osseous cochlea, and completes the deficiency which is left by the lamina spiralis. It consists of two membranes, namely,

the basilar membrane and the membrane of Reissner, which enclose between them the ductus cochlearis, or scala media. The cochlear tube in the recent state is therefore divided into three spiral passages, namely, (1) the scala tympani, (2) the scala vestibuli, and (3) the scala media. The scala vestibuli is continuous with the scala tympani at the cupola through means of an aperture, called the *helicotrēma;* and at the base of the cochlea it opens upon the anterior wall of the vestibule. The scala tympani commences at the fenestra rotunda, and in the recent state is separated from the tympanic cavity by the secondary membrane of the tympanum. The scala media, or ductus cochlearis, communicates, near its lower end, with the saccule by means of the canalis or ductus reuniens of Hensen. The scala vestibuli and scala tympani contain perilymph, which is continuous with the perilymph of the vestibule and osseous semicircular canals. The scala media contains endolymph, which is continuous with that of the saccule.

Basilar Membrane.—The basilar membrane extends from the free margin of the lamina spiralis to the *crista basilaris*, or lower

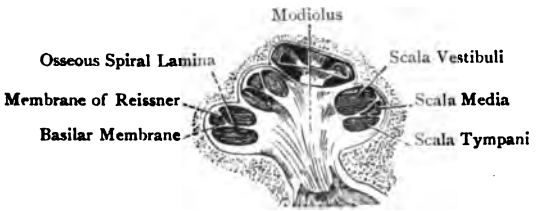


FIG. 626.—VERTICAL SECTION OF THE COCHLEA OF A FŒTAL CALF, SHOWING THE SCALÆ AND MODIOLUS (KOLLIKER).

part of the **spiral ligament,** which ligament is a thickening of the periosteum of that part of the outer wall of the cochlea which forms the outer wall of the scala media, or ductus cochlearis. It separates the scala media from the scala tympani, and is divisible into two zones, inner and outer. The inner zone is called the *zona arcuata*, and it supports the organ of Corti. The outer zone is called the *zona pectinata*, and it extends from the foot-plates of the outer rods of Corti to the crista basilaris. The basilar membrane consists of a homogeneous membrana propria, with fibres embedded in it, the fibres being most numerous in the zona pectinata.

Membrane of Reissner.—This is a delicate membrane which extends from the upper surface of the lamina spiralis, a short distance from its free margin, to the outer wall of the cochlea, where it is attached to the periosteum at a point a short distance above the outer attachment of the basilar membrane. It separates the scala media from the scala vestibuli, and consists of a very delicate connective-tissue membrane, lined on each side with a single layer of squamous epithelium.

The **scala media,** or **ductus cochlearis,** is situated between the

basilar membrane and the membrane of Reissner. It is triangular in transverse section, and presents a roof, an outer wall, and a floor. The **roof** is formed by the membrane of Reissner, which, as just stated, separates the scala media from the scala vestibuli. The **outer wall** is formed by the outer wall of the cochlea and its periosteum, between the external attachments of the basilar membrane and the membrane of Reissner. The periosteum in this region is much thickened, and forms the **spiral ligament of the cochlea,** the lower part of which gives rise to the crista basilaris. The **floor** is formed by (1) the basilar membrane, and (2) the portion of the upper surface of the lamina spiralis which lies external to the attachment of the membrane of Reissner. As stated, the basilar membrane separates the scala media from the scala tympani. The scala media terminates above in a closed extremity at the cupola, and it has a similar mode of termination at the base of the cochlea. Near its lower blind extremity it receives the canalis or ductus reuniens of Hensen, by which it communicates with the saccule.

As just stated, part of the floor of the scala media is formed by that portion of the upper surface of the lamina spiralis which lies external to the attachment of the membrane of Reissner. In the recent state it is of some thickness, which is due to a thickening of its periosteal covering. This fibrous thickening forms the **limbus laminæ spiralis.** Its outer margin is crescentic, the deep notch being called the *sulcus laminæ spiralis.* The sulcus has two lips, upper and lower. The upper lip is called the *labium vestibulare,* the upper surface of which is marked by several interlacing prominences and grooves. At the free margin of this labium the prominences assume the form of tooth-like projections, which are known as the **auditory teeth.** The lower lip of the sulcus is called the *labium tympanicum.* It is continued into the basilar membrane, and is perforated by a great number of apertures for the branches of the cochlear division of the auditory nerve.

Organ of Corti.—Over the upper surface of the inner part (zona arcuata) of the basilar membrane the epithelium undergoes remarkable modification, and gives rise to the **organ of Corti.** The constituent parts of this very complicated organ are as follows:

1. The rods of Corti.
2. The auditory or hair-cells.
3. The cells of Deiters.
4. The cells of Hensen and of Claudius.
5. The lamina reticularis.
6. The membrana tectoria.

The **rods of Corti** are arranged in two rows, inner and outer. The rods of the inner row are spoken of as the **inner rods,** and those of the outer row as the **outer rods.** Each rod consists of a foot-plate or base, an intermediate portion, and a head, which latter represents the upper extremity. The **foot-plate,** which is expanded, rests upon the zona arcuata of the basilar membrane, and the foot-plates of the inner rods are separated from those of the outer rods by a slight

interval. As the rods rise the **intermediate portions** of the inner and outer rods incline towards each other, and the **heads** of the two sets of rods come into contact. In this manner a triangular tunnel is enclosed between the two sets of rods and the basilar membrane, which is called the **tunnel of Corti.** This tunnel extends along the entire length of the scala media, or ductus cochlearis.

The inner and outer rods present certain differences.

The **inner rods** are more numerous than the outer, there being from 5,000 to 6,000 of the former, and about 4,000 of the latter. They incline upwards and outwards. The **head** of each is

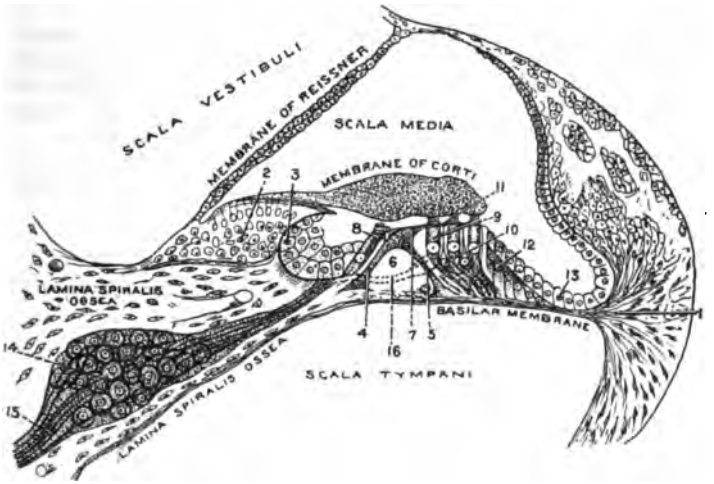


FIG. 627.—THE ORGAN OF CORTI (WIEDERSHEIM, AFTER LAVDOWSKY).

1. Spiral Ligament
2. Limbus
3. Sulcus Spiralis
4. Inner Rod of Corti
5. Outer Rod of Corti
6. Tunnel of Corti
7. Phalangeal Process of Outer Rod
8. Inner Hair-cells
9. Outer Hair-cells
10. Cells of Deiters
11. Lamina Reticularis
12. Cells of Hensen
13. Cells of Claudius
14. Spiral Ganglion
15. Cochlear Nerve
16. Nerve-fibres to Hair-cells

directed outwards and presents a concavity, above and below which there is a projecting portion, so that it resembles, somewhat, the upper extremity of the ulna, with its great sigmoid cavity and olecranon and coronoid processes. The concavity on the head of the inner rod receives the round portion of the head of the outer rod. Finally, the inner rods are shorter than the outer rods. The **outer rods** are less numerous and longer than the inner, and they incline upwards and inwards. The **head** of each is divisible into two parts—inner and outer. The *inner part* is round, and is received into the concavity on the outer aspect of the head of the inner rod. The *outer part* is prolonged into a beak-like pro-

jection, called the **phalangeal process,** which forms part of the lamina reticularis, to be presently described.

The **auditory** or **hair-cells** are arranged in two sets—inner and outer. The **inner hair-cells** are situated internal to the row of inner rods, and are disposed in a single row. They are from 3,000 to 4,000 in number. Their free extremities, which lie close to the heads of the inner rods, are each provided with a tuft of short, hair-like filaments. The deep, nucleated ends of the cells are related to the terminal arborizations of nerve-fibres. Internal to the row of inner air-cells there are two or more rows of columnar cells, which are continuous with the columnar epithelium of the sulcus spiralis laminæ. The **outer hair-cells** are disposed in three or four rows external to the outer row of rods. They are much more numerous than the inner hair-cells. Their free extremities, like those of the inner cells, are each provided with a tuft of short, hair-like filaments, and their deep, nucleated ends are related to the terminal arborizations of nerve-fibres.

The **cells of Deiters,** which are sustentacular, are situated between the rows of outer hair-cells. They rest by an expanded base upon the

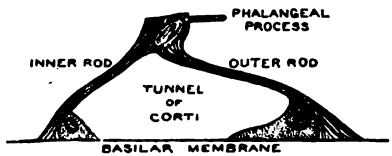


FIG. 628.—A PAIR OF RODS OF CORTI, FROM THE RABBIT'S COCHLEA, SIDE VIEW (HIGHLY MAGNIFIED) (SCHÄFER IN QUAIN'S 'ANATOMY').

basilar membrane, where they support the outer hair-cells; and their narrow, tapering upper extremities extend to the lamina reticularis, where they expand slightly, and form phalangeal processes of that lamina. Each cell is nucleated.

The **cells of Hensen** are disposed as a continuous layer, external to, and in continuation of, the lamina reticularis.

External to the cells of Hensen there are the columnar **cells of Claudius.**

The **lamina reticularis** is a delicate layer which extends between the heads of the outer rods of Corti and the cells of Hensen. It is composed of **phalangeal processes,** which are derived from (1) the heads of the outer rods of Corti, and (2) the upper extremities of the cells of Deiters. Between the processes there are apertures, through which the outer extremities of the outer hair-cells, with their tufts of hair-like filaments, project. The phalangeal processes are arranged in rows, those of the innermost row being formed by the phalangeal processes of the heads of the outer rods of Corti.

The **membrana tectoria**, or **membrane of Corti**, is an elastic membrane which extends from the upper surface of the lamina spiralis,

near and external to the lower attachment of the membrane of Reissner, to the outer hair-cells. It covers the limbus laminæ spiralis, the labium vestibulare, the inner hair-cells, and the inner and outer rods of Corti.

Auditory Nerve.—The auditory nerve, within the meatus auditorius internus, breaks up into two divisions—vestibular and cochlear.

The **vestibular nerve,** as it traverses the meatus auditorius internus, presents a gangliform enlargement, called the **ganglion of Scarpa,** and it divides into three branches. These enter the vestibule through the foramina in the superior vestibular area of the lamina cribrosa at the deep end of the internal meatus. They are distributed to the macula acustica utriculi and to the cristæ acusticæ of the ampullæ of the superior and external semicircular canals.

The **cochlear nerve,** in the meatus auditorius internus, furnishes two branches—one to the macula acustica sacculi, and the other to

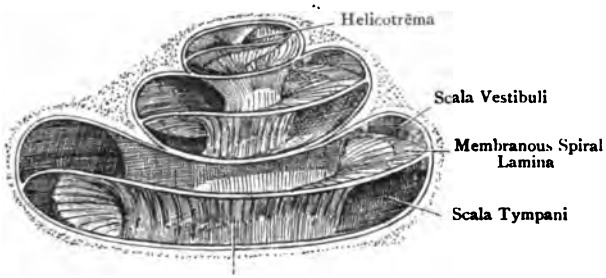


FIG. 629.—SECTION OF THE COCHLEA, SHOWING THE DISTRIBUTION OF THE COCHLEAR BRANCH OF THE AUDITORY NERVE (MAGNIFIED) (HIRSCHFELD AND LEVEILLÉ).

the crista acustica of the ampulla of the posterior semicircular canal. The filaments of the former, which has a gangliform enlargement, pass through the foramina in the inferior vestibular area of the lamina cribrosa, and the latter passes through the foramen singulare in the lamina cribrosa. The cochlear nerve, having parted with these two branches, breaks up into filaments which pass through the foramina of the cochlear area of the lamina cribrosa, and so reach the base of the modiolus of the cochlea. They traverse the canals of the modiolus, from which they pass into the canals between the two layers of the lamina spiralis. In doing so they have to cross the **spiral canal** of the modiolus, which is situated close to the attached margin of the lamina spiralis. This canal contains a ganglion, called the **spiral ganglion,** which pursues the windings of the canal, and consists of bipolar nerve-cells. As the auditory fibres pass from the canals of the modiolus into the canals of the lamina spiralis, the course of each fibre is probably

interrupted by a bipolar cell of the spiral ganglion in the spiral canal. The nerve-fibres, having emerged from these bipolar cells, traverse the canals between the two layers of the lamina spiralis. Having lost their medullary sheaths, they emerge through the foramina of the labium tympanicum on the outer margin of the limbus laminæ spiralis, and enter the basilary membrane, where they terminate in arborizations which are connected with the inner and outer hair-cells.

Blood-supply of the Labyrinth.—The labyrinth derives its blood from the **internal auditory artery,** which is a branch of the basilar artery. The vessel traverses the meatus auditorius internus, and divides at its deep end into two branches—vestibular and cochlear. The **vestibular artery** supplies the utricle, saccule, and semicircular canals, and the **cochlear artery** supplies the cochlea.

The **veins** of the labyrinth ultimately join, for the most part, to form one vessel, called the **internal auditory vein,** which opens into the inferior petrosal sinus. The aqueductus cochleæ and the aqueductus vestibuli each transmit a vein, that which passes through the former terminating in the inferior petrosal sinus or in the bulb of the internal jugular vein, and that which passes through the latter terminating in the superior petrosal sinus.

Development of the Ear.—The **membranous labyrinth** is developed from the **auditory pit,** which is an invagination of the external epiblast, on either side, over the upper end of the first visceral cleft, in the region of the hind-brain. This pit becomes closed by the fusion of its margins, and thus gives rise to the **otic** or **auditory vesicle.** This vesicle consists of a neck and a body. The **neck** undergoes elongation, and forms the ductus endolymphaticus. The **body** also undergoes elongation, and its lower portion gives rise to the **cochlea,** whilst its upper portion becomes developed into the **semicircular canals.** The intervening portion of the body becomes partitioned off into the **utricle** and **saccule.** The foregoing structures are all of epiblastic origin.

A periotic cartilaginous capsule is now formed around them, which is ossified from opisthotic, pro-otic, epiotic, and pterotic centres, and gives rise to the **osseous labyrinth.**

The **auditory nerve** is developed from a ridge of epiblast, called the **neural crest,** which is connected on either side with the dorsal aspect of the neural canal.

The **tympanum** and the **Eustachian tube** are developed from the first visceral cleft—that is to say, the cleft between the first or mandibular and second or hyoid arches. At the bottom of this cleft the epiblast and hypoblast meet, and the tympanum and Eustachian tube are developed from the hypoblast.

The **membrana tympani** is developed from the mesoblast which grows between the epiblast and hypoblast at the bottom of the first visceral cleft.

The **meatus auditorius externus** is developed from the epiblast at the bottom of the first visceral cleft.

The **auricle** or **pinna** is developed from certain prominences which make their appearance upon the mandibular and hyoid arches.

The development of the **tympanic ossicles** has been stated in connection with their description.

GUIDE TO THE HEAD AND NECK.

Back of the Scalp and Neck.—The landmarks having been studied, the skin is to be removed by making the following incisions : one is to be carried along the median line from the level of the seventh cervical spinous process to the vertex of the skull, and this incision may be prolonged to the root of the nose ; a second is to be made from the upper part of the auricle, and a third from the acromial region, both of these meeting the first incision. On reflecting the flaps of skin thus marked out great care has to be exercised, as the skin and superficial fascia are very closely adherent. The cutting edge of the knife should be directed towards the skin, so as to score it, and in doing so the roots of the hairs will be severed. At the same time the dissector will note the strong fibrous processes which bind the superficial fascia to the skin.

The cutaneous nerves are to be displayed at once, and followed to their terminations. The great occipital nerve, with the occipital artery lying external to it, will be met with piercing the complexus, and, it may be, the trapezius, about ½ inch from the median line, and the occipital venous plexus is to be kept in view. The least, or third, occipital nerve, very minute, will be found internal to the great occipital, and the small occipital nerve is to be found along the posterior border of the sterno-cleido-mastoid muscle. The great auricular nerve lies immediately below the small occipital, and turns upwards and forwards over the upper part of the sterno-cleido-mastoid towards the lobule of the auricle, where its mastoid, auricular, and facial branches are to be shown. The superficial or transverse cervical nerve can only be shown initially. It appears immediately below the great auricular, and at once passes horizontally forwards over the sterno-cleido-mastoid, where it must be left in the meantime. The spinal accessory nerve is to be caught where it appears from beneath the posterior border of the sterno-cleido-mastoid, about its centre and below the superficial cervical. It is to be followed downwards and outwards across the posterior triangle to the anterior border of the trapezius, beneath which it disappears. Accompanying it, and lying on a lower level than it, an effort should be made to show the two branches which the anterior primary divisions of the third and fourth cervical nerves furnish to the trapezius. The descending superficial branches of the cervical plexus will be met with at the posterior border of the sterno-cleido-mastoid, immediately below the spinal accessory. If they appear as one trunk they will soon divide into suprasternal, supraclavicular, and supra-acromial ; but these nerves, in this position of the subject, can only be seen at their commencement.

The internal branches of the posterior primary divisions of the third, fourth, and fifth cervical nerves are to be displayed as they pierce the trapezius close to the median line, and they are to be followed outwards.

Behind the auricle, over the mastoid process, the mastoid glands are to be carefully looked for, and the occipital gland, or glands, will be met with over the cranial insertion of the trapezius, or, it may be, the complexus. Along the posterior border of the sterno-cleido-mastoid the glandulæ concatenatæ are to be looked for.

The cervical part of the trapezius is to be dissected, and its anterior border clearly defined, with the spinal accessory nerve and branches of the third and fourth cervical nerves passing beneath it. The posterior portion of the upper part of the sterno-cleido-mastoid is also to be clearly defined. The interval between the trapezius and the sterno-cleido-mastoid, partially visible in this position of the subject, is the posterior triangle. Within it are to be partially dissected the following structures: a small angle of the complexus muscle pierced by the great occipital nerve, provided the trapezius is not well developed; a portion of the splenius muscle, flat and broad, and directed upwards and outwards; and a portion of the levator anguli scapulæ.

The occipitalis muscle is next to be dissected, and the epicranial aponeurosis, upon which its fibres end, is to be displayed. The close connection between this aponeurosis and the superficial fascia is to be noted, whereas it is only loosely connected to the subjacent periosteum or pericranium. Behind the auricle the retrahens auriculam muscle is to be shown passing between the mastoid process and the convexity of the concha. Lying deeply in the hollow between the mastoid process and the auricle careful dissection will bring into view the posterior auricular nerve and artery, both of which are to be followed to their distribution. The posterior auricular vein is of importance, because, in conjunction with the posterior division of the temporo-maxillary vein, it forms the external jugular vein. Above the auricle the attollens auriculam muscle is to be shown, lying upon the temporal fascia. In front of the auricle, and continuous with the preceding muscle, will be found the attrahens auriculam. The latter two muscles will be found to receive twigs from the temporo-facial division of the facial nerve.

Frontal Region.—The dissection of the frontal region is next to be overtaken, the head being well raised upon a block. The frontalis muscle and front part of the epicranial aponeurosis are to be dissected. The supra-orbital nerve, of large size, is to be carefully displayed. It will be found ascending in line with the junction of the inner third and outer two-thirds of the supra-orbital arch, in company with the supra-orbital artery, and it lies at first beneath the upper part of the orbicularis palpebrarum and the frontalis muscles. Its twigs to the upper eyelid are to be looked for, and its main branches are to be followed towards the vertex of the skull. The supra-trochlear nerve, of small size, will be found internal to the supra-orbital, and in line with the inner canthus of the eye. It is accompanied by the frontal artery. The supra-orbital vein is to be shown passing downwards and inwards to join the frontal vein in the region of the inner canthus, the resultant vessel being the angular vein, which is the commencement of the facial vein. A communicating vessel is to be looked for passing from the supra-orbital vein to the supra-orbital notch, after traversing which it communicates with the superior ophthalmic vein within the orbit.

Temporal Region.—The attollens and attrahens auriculam muscles have been already referred to. Directly in front of the tragus of the auricle there will be found the auriculo-temporal nerve and the superficial temporal artery and vein. The nerve lies between the tragus and the artery, and its meatal, anterior auricular, and temporal branches are to be shown, the first two sets of branches requiring considerable care in their display. The temporal branches of the temporo-facial division of the facial nerve are to be kept in view at this stage. The superficial temporal artery, in two divisions, anterior and posterior, is to be dissected, and special attention is to be given to the tortuous anterior division, which is of some surgical importance. The temporal branch of the temporo-malar or orbital nerve (from the superior maxillary division of the fifth cranial nerve) will be met with piercing the temporal fascia about 1 inch above the anterior part of the zygoma, and close behind the marginal process on the temporal border of the malar bone. Its cutaneous distribution is somewhat limited.

The temporal fascia, or aponeurosis, is next to be dissected. In the region of the zygomatic arch it will be found to consist of two laminæ, between which, in addition to fat, will be found the orbital branch of the superficial temporal artery on its way to the outer part of the orbicularis palpebrarum

muscle. In removing this fascia the dissector will note that its deep surface gives origin to the superficial fibres of the temporal muscle superiorly. The upper portion of the temporal muscle is then to be studied, but it cannot be followed at the present time beyond the level of the zygomatic arch.

At this stage the dissector, in association with his companion, may take the steps necessary for the removal of the brain, the subject being now assumed to have lain for two days face downwards. It may, however, be preferable to complete the dissection of the back of the neck.

The trapezius is to be divided by a vertical incision about 1 inch from the spines of the vertebræ, in association with the dissector of the upper limb. The spinal accessory nerve is then to be dissected along the deep surface of the muscle, in company with the superficial cervical artery, and the plexiform communication between the spinal accessory and the branches from the anterior primary divisions of the third and fourth cervical nerves is to be shown. The insertion of the sterno-cleido-mastoid is to be in great part detached and turned forwards towards the auricle. Assuming that the dissector of the upper limb has paved the way by dividing and reflecting the rhomboid muscles and the serratus posticus superior, the splenius muscle is then to be fully dissected in co-operation with the dissector of the upper limb. Its twofold condition at its insertion, namely, the splenius capitis and the splenius colli, is to be clearly brought out. The muscle is thereafter to be divided by a vertical incision about 1 inch from the spines of the vertebræ, a procedure which will enable the dissector to display more fully the twofold condition of the muscle at its insertion.

The trachelo-mastoid and complexus muscles fall next to be dissected, the former being very narrow and ribbon-like, whilst the latter is a large and powerful muscle, and is pierced by the great occipital nerve. Tendinous intersections are to be looked for in these muscles, one in each, and in the case of the complexus the condition of its mesial portion is to be carefully looked to. The dissector will note that this portion presents an intervening tendon, with a fleshy belly at either end, thus accounting for the name *biventer cervicis*, by which the inner portion of the complexus is known.

At this stage the second part of the occipital artery falls to be dissected. Its princeps cervicis branch (arteria princeps cervicis) is to be dissected very carefully, and preserved for immediate further dissection. The trachelo-mastoid is to be divided, and the relation of structures in the mastoid region from the surface downwards is to be carefully noted. The complexus is to be divided about 2 inches below its insertion, and on reflecting the muscle the dissector should follow downwards the arteria princeps cervicis. About the level of the spine of the axis he will find that it anastomoses with the deep cervical artery, which, he will note, ascends beneath the complexus. The subsequent and final stage of this dissection consists in displaying the structures of the infra-axial and supra-axial regions. Below the level of the spine of the axis the semispinalis colli muscle, as regards its fourfold insertion, is to be made clear. The origin of this muscle must be dissected in concert with the dissector of the upper limb. Ascending upon it there is, as stated, the deep cervical artery. Passing inwards upon it will be found the internal branches of the posterior primary divisions of the third, fourth, and fifth cervical spinal nerves, whilst those of the sixth, seventh, and eighth nerves pass inwards underneath the muscle. When the semispinalis colli is removed the upper part of the multifidus spinæ falls to be dissected. The interspinales muscles, along with the ligamentum nuchæ, are next to receive attention, and the tendinous slips of insertion of the cervicalis ascendens and transversalis cervicis into tubercles (posterior tubercles) of transverse processes are to be made evident. At this stage the dissector should familiarize himself with the relative position of muscles, proceeding from the tubercles (posterior tubercles) of cervical transverse processes, and passing backwards to the cervical spines.

Above the level of the spine of the axis four muscles and the suboccipital triangle, with its contents, require very careful dissection. The obliquus capitis inferior will be found extending obliquely outwards and upwards from

the spine of the axis to the transverse process of the atlas, and the dissector will note that the great occipital nerve, preparatory to piercing the complexus, winds round the lower border of the inferior oblique in a backward direction. The obliquus capitis superior will be found extending upwards and inwards from the transverse process of the altas to the occipital bone between the outer parts of the superior and inferior curved lines. The rectus capitis posticus major is to be shown extending from the spine of the axis upwards and outwards to the outer part of the inferior curved line of the occipital bone and the subjacent area. The rectus capitis posticus minor is partially visible internal to the preceding muscle, but is also under cover of it. It will be recognised as a fan-shaped muscle, lying very deeply, and extending from the posterior arch of the atlas, close to the posterior tubercle, in a radiating manner upwards to the inner third of the inferior curved line of the occipital bone and the subjacent area. The suboccipital triangle will now be exposed, lying between the inferior oblique, superior oblique, and rectus capitis posticus major. Within this triangle the dissector, by exercising great care, should expose and study the following structures: (1) the posterior primary division (undivided) of the first cervical or suboccipital nerve, lying in close contact with the vertebrarterial groove of the atlas; (2) the third part of the vertebral artery; (3) the posterior occipito-atlantal ligament (one half), and one half of the posterior arch of the atlas. The suboccipital plexus of veins also occupies this triangle, from which the blood is conveyed away by the vertebral and deep cervical veins.

Up to this stage of the dissection it may be presumed that the period allowed for the subject to lie with its face downwards has expired.

Removal of the Brain.—The brain may be removed whilst the subject lies upon its face, but there is no objection to removing it whilst the subject lies upon its back. The scalp having been previously dissected, together with the temporal fascia and the origin of the temporal muscle, the cranium is to be cleared for the saw by carrying a scalpel around it, passing about 1 inch above the orbits, and about ½ inch above the external occipital protuberance. The external table of the cranial bones is then to be sawn through, and thereafter the internal table is to be cracked by means of a chisel and mallet. The calvaria is then to be eased all round by inserting the chisel, and forcibly raised from the dura mater, which is adherent to it. The dura mater, being now exposed, is to be carefully sponged and studied *in situ*. The superior longitudinal sinus, which runs in an antero-posterior direction in the median line, is to be laid freely open, and its interior examined. On either side of this sinus the outlines of the Pacchionian bodies are to be noted, and the ramifications of the middle meningeal artery are to receive attention.

The dura mater is then to be divided on a level with the sawn margin of the skull, its mesial attachments in front and behind being left intact. On being raised towards the median line, the subdural space will be freely exposed, and the arachnoid membrane and pia mater are to be examined. The cerebral veins, as they pass to the superior longitudinal sinus, are to receive attention, and it should be noted that the direction of these veins is from behind forwards, so that the current of blood in them is opposed to that in the superior longitudinal sinus. The cerebral hemisphere is now to be slightly pulled away from the median line in order to expose the falx cerebri. When this process has been studied, its attachment to the crista galli is to be severed, and the process is to be thrown backwards towards the tentorium cerebelli, after which the brain is to be removed.

Assuming the subject to be lying upon its face, the posterior cerebral lobes are to be raised, which will expose the tentorium cerebelli. This is to be divided near the superior border of the petrous part of the temporal bone, and for a short distance along the course of the lateral sinus on either side, but the sinus is not to be laid open. At the same time the fourth and fifth pairs of nerves are to be divided. Exactly in the median line the vena magna Galeni is to be cut as it is about to enter the straight sinus. The tentorium cerebelli, along with the falx cerebri, is then to be turned backwards, which will expose the cerebellum. The cerebellar hemispheres are next to be care-

fully raised from the cerebellar fossæ of the occipital bone, and the spinal cord, vertebral arteries, and spinal accessory nerves are to be divided as low down in the spinal canal as possible.

The hypoglossal, pneumogastric, glosso-pharyngeal, auditory, facial, sixth and third nerves are next to be divided, as near as possible to where they leave the cranial cavity. The infundibulum, in the median line, is to be cut, and anterior to it on either side the internal carotid artery is to be divided, along with the optic nerve, which lies directly in front of it. The brain is now to be entirely removed, care being taken to remove along with it the olfactory lobes.

Assuming the subject to be lying upon its back, the mode of procedure will be the reverse of the foregoing.

Before placing the brain in hardening fluid the base of the encephalon is to be carefully studied. Its component parts are to be observed as follows: the medulla oblongata, the pons Varolii, the cerebellum, and portions of the cerebral hemispheres. The crura cerebri will be seen diverging from each other above the pons; anteriorly the optic tracts will be seen to converge and form the optic commissure; and within the enclosed rhomboidal area there will be seen the locus perforatus posticus, the corpora albicantia, the tuber cinereum, and a tag of the infundibulum. The stem of the fissure of Sylvius is to be noted, with the middle cerebral artery traversing it, and the locus perforatus anticus at its inner end. In front of the fissure is the orbital area of the frontal lobe of the cerebral hemisphere, and behind it the prominent temporal lobe. The arachnoid and pia mater are to be carefully examined. Over the gyri they will be found to be in close contact, but in certain situations intervals, called cisternæ, exist between them. These are as follows: (1) cisterna magna, between the cerebellum and the medulla oblongata; (2) cisterna pontis, on the ventral aspect of the pons Varolii, in which the basilar artery lies; and (3) cisterna basalis, over the interpeduncular region, in front of the pons, and containing the circle of Willis. The superficial origins of the cranial nerves, including the olfactory lobe, are to be accurately observed, as well as the arrangement of the arteries. The arteries should be studied in the following order: the two vertebrals, the basilar, the two posterior cerebrals, the trunk of each internal carotid, the two anterior cerebrals, joined by the anterior communicating, the middle cerebrals, and the two posterior communicating arteries. In connection with the foregoing arteries the circle of Willis is to receive careful attention. The anterior and posterior choroidal arteries, as well as the lenticulo-striate arteries, are to be kept carefully in view.

The arachnoid and pia mater are then to be removed as carefully as possible, in order to expose the gyri and sulci to the influence of the hardening fluid. In doing so a gentle stream of water may be advantageous, but the cranial nerves are not to be interfered with, though the arteries may now be taken away. Thereafter the brain, base upwards, is to be carefully packed in a crock containing hardening fluid, and laid aside for future dissection.

Cranial Cavity.—The venous sinuses, cranial nerves, and arteries at the base of the skull are next to be dissected. The superior longitudinal sinus along the upper border of the falx cerebri has been already studied. Along the lower border of the falx cerebri the inferior longitudinal sinus, of small size, is to be followed backwards into the straight sinus, which latter is situated along the line of junction of the falx cerebri and tentorium cerebelli. The occipital sinus is to be shown within the falx cerebelli along the course of the internal occipital crest, as are also the inferior occipital or marginal sinuses on either side of the vermiform fossa. The torcular Herophili is to be laid open. It will usually be found upon the right side of the internal occipital protuberance. The lateral sinus on either side is to receive very careful attention, and in studying it the dissector should make himself familiar with the line, upon the exterior of the head, which indicates its winding course. This sinus should be laid open quite up to the postero-external compartment of the jugular foramen.

The cavernous sinus is then to be dissected with the greatest care, keeping

in view the third, fourth, ophthalmic, superior maxillary, and sixth nerves, as well as the cavernous sympathetic plexus. Anteriorly the sinus will be found to receive its blood from the orbit through means of the ophthalmic vein or veins. It is connected with its fellow of the opposite side by two venous channels, namely, the anterior and posterior intercavernous sinuses (so-called circular sinus), lying in front of and behind the pituitary body. The cavernous sinus is to be shown dividing posteriorly into the superior and inferior petrosal sinuses. The superior petrosal sinus is to be followed along the superior border of the *pars petrosa* to the point where it opens into the lateral sinus, and the inferior petrosal sinus is to be laid open between the *pars petrosa* and the basilar process of the occipital bone as far as the antero-internal compartment of the jugular foramen, through which it passes independently. The transverse or basilar sinus is represented by several veins arranged in a plexiform manner, and lying over the basilar process of the occipital bone. It forms a connection between the right and left inferior petrosal sinuses.

The cranial nerves are next to receive attention, as they make their exit from the cranial cavity. The olfactory lobes have been removed along with the brain, and the olfactory filaments traverse the foramina in the cribriform plate of the ethmoid bone. Lying upon each half of this plate there is the nasal nerve, accompanied by the anterior ethmoidal artery, both lying beneath the dura mater, and passing forwards and inwards towards the fore part of the side of the crista galli, where they disappear through the nasal slit. The optic nerve will be found at the optic foramen, where it has the internal carotid artery directly behind it. The third, fourth, ophthalmic, superior maxillary, and sixth nerves are to be met with in close relation to the cavernous sinus. The first four of these nerves will be found in relation to the outer wall of the sinus, and the sixth nerve in close contact with the outer wall of the cavernous part of the internal carotid artery within the sinus. The dissection of the cavernous sympathetic plexus, in close relation to the artery, requires considerable care, and the artery itself, with its branches, is to be shown.

The Gasserian ganglion on the large sensory root of the fifth nerve is to be carefully displayed, the small motor root of the nerve lying underneath the ganglion. The locality of the ganglion is the Gasserian depression on the superior surface of the *pars petrosa* near the apex. From the ganglion the ophthalmic nerve is to be followed forwards to the outer wall of the cavernous sinus, the superior maxillary nerve forwards to the foramen rotundum, and the inferior maxillary nerve, along with the motor root of the fifth nerve, downwards to the foramen ovale. At the entrance to the meatus auditorius internus will be found the seventh and eighth nerves, with the internal auditory artery. At the jugular foramen will be found the ninth, tenth, and eleventh nerves, as well as the lateral and inferior petrosal sinuses, and the relative position of the structures at this foramen should receive careful attention. The twelfth nerve will be met with at the anterior condylar foramen, and it is to be noted that it pierces the dura mater in two bundles.

The various structures passing through the foramen magnum must be mastered.

The different meningeal arteries will be found fully described in the text. The sphenoidal fissure and the transmitted structures should be postponed until the dissection of the orbit is being overtaken.

The pituitary body is now to receive attention. It will be found in the pituitary fossa or sella turcica of the sphenoid bone, where it is largely covered by the fold of dura mater called the diaphragma sellæ. If in favourable condition, it should be carefully removed, and studied according to the description given of it in the text.

The interior of the skull, having been carefully cleaned, is now to be protected by placing upon the interior of the base pieces of cotton-wool, soaked in preservative fluid. Thereafter the calvaria is to be replaced, or, if it is not now available for use, the saturated cotton-wool is to be protected from evaporation by the usual means familiar to all.

Side of the Neck.—The subject being now placed with its face upwards,

it is essential that the dissector should, in the first place, make himself thoroughly familiar with the landmarks of the side and front of the neck, particularly the latter in connection with goitre, laryngotomy, and tracheotomy.

The skin is to be removed by means of the following incisions: a mesial incision is to be carried from the chin to the upper border of the manubrium sterni; another from the lower end of the preceding outwards along the clavicle to the acromion process of the scapula; and a third from the chin along one half of the base of the inferior maxilla to the angle of that bone, and thence to the mastoid region. These incisions have to be made with great care, on account of the thinness of the skin and the important subcutaneous structures.

The muscular sheet, called the platysma myoides, requires very careful dissection, inasmuch as its fasciculi are very pale and delicate, but principally because these fasciculi are embedded in the superficial fascia. Inexperienced dissectors may be surprised when informed that they have removed the muscle in their haste to expose what lies underneath it. The muscle, after examination, is to be reflected from below upwards, and laid over the side of the face. This must be done with the greatest care. Thereafter the following veins are to be dissected, namely, the anterior jugular, near the median line of the neck; the external jugular, crossing the sterno-cleido-mastoid; and the posterior jugular, which is the most external occipital vein. The dissector must be prepared for finding these veins not quite normal. Along the course of the external jugular vein the superficial cervical glands are to be displayed. The nerves which fall to be dissected at this stage are as follows: (1) the great auricular, passing upwards and forwards over the sterno-cleido-mastoid towards the lobule of the auricle; (2) the superficial or transverse cervical, passing forwards over the sterno-cleido-mastoid, and beneath the external jugular vein; and (3) the suprasternal, supraclavicular, and supra-acromial, which three take a downward course. The inframandibular or cervical branch of the facial nerve must also be dissected.

Posterior Triangle.—The dissection of this region should be accomplished in the course of the first four days after the subject has been placed with its face upwards, in order that the dissectors of the neck and upper limb may work in concert. In his mode of procedure the dissector must keep carefully before him the disposition of the deep cervical fascia, which undoubtedly is of a very complicated and, it may be, perplexing nature. But, perhaps, if he masters the description given in the text as a preliminary, it may clear up matters. The boundaries of the posterior triangle are now to be clearly defined, though in the dissection of the back of the neck they would be apparent to a certain extent. The deep cervical fascia, as it extends from the anterior border of the trapezius to the posterior border of the sterno-cleido-mastoid, is to be studied, and its deep expansion to embrace the posterior belly of the omo-hyoid is to be kept in view. This belly is to be at once laid bare and studied. The dissector will note that it divides the posterior triangle into two, a superior or occipital triangle, and an inferior or subclavian (supraclavicular) triangle. The occipital triangle should receive attention first. The structures within it have been already referred to, whilst the subject lay upon its face, *e.g.*, the superficial group of branches of the cervical plexus of nerves, the spinal accessory nerve, the branches from the third and fourth cervical nerves to the trapezius, the glands known as the glandulæ concatenatæ, and the following muscles in part: a small angle of the complexus, provided the trapezius is not well developed at its occipital origin; the splenius capitis; the levator anguli scapulæ; and the scalenus medius. If the posterior border of the sterno-cleido-mastoid be pulled forwards and maintained in that position by hooks, there is no objection to the dissection of the very complicated cervical plexus being partially made at this stage. The dissector, however, must first master the description which is given of the plexus in the text, from which he may see that the evolution of its branches is a complicated process. No hard-and-fast lines

can therefore be laid down for the guidance of the dissector. He will certainly find the phrenic nerve descending upon the scalenus anticus muscle. Piercing the scalenus medius he should find the following nerves, in order from above downwards: (1) the nerve to the rhomboids; and (2) the upper two roots of the posterior thoracic nerve, or external respiratory nerve of Bell.

The subclavian or supraclavicular triangle now falls to be dissected. Its boundaries will by this time be self-evident, as well as the structures forming, and related to, its roof, in connection with which the supraclavicular glands are to be noted. The third part of the subclavian artery must be carefully dissected, as well as the nerve-trunks of the brachial plexus, all emerging from behind the scalenus anticus muscle. Possibly the posterior scapular artery may be found to arise from the third part of the subclavian. The subclavian vein will not be visible, inasmuch as it lies under cover of the clavicle; neither will the suprascapular vessels. The transverse cervical vessels, however, will be found within the triangle, where the posterior belly of the omo-hyoid is about to disappear beneath the posterior border of the sterno-cleido-mastoid. The relative positions of the upper, middle, and lower nerve-trunks of the brachial plexus to the third part of the subclavian artery are to be made perfectly clear. The formation of the entire plexus is to be made quite manifest. Arising from the front of the upper nerve-trunk will be found the nerve to the subclavius muscle, which is of small size, and descends over the artery and behind the clavicle. The suprascapular nerve, of large size, is to be found arising from the back of the upper nerve-trunk, and taking a course downwards and outwards.

At this stage the dissectors of the head and upper limb should work in concert, and the clavicle and subclavius muscle should be divided about their centre. After a certain amount of dissection an instructive view will be obtained of (1) the continuity between the third part of the subclavian artery and the first part of the axillary; (2) the subclavian vein; (3) the suprascapular vessels; (4) the cords of the brachial plexus; and (5) the infraclavicular branches of the plexus.

Anterior Triangle of the Neck.—The deep cervical fascia is to be dissected as far as possible, without going too deeply at the present stage. The suprasternal space, or space of Burns, is to be examined, and the portion of the deep cervical fascia which extends between the upper part of the anterior border of the sterno-cleido-mastoid and the angle of the inferior maxilla is to be noted. The sterno-cleido-mastoid muscle is to be completely dissected, and its complicated relations studied. The sterno-hyoid, sterno-thyroid, and the anterior belly of the omo-hyoid are also to be dissected, always keeping in view the disposition of the deep cervical fascia. In the dissection of these muscles the descendens cervicis (hypoglossi) nerve is to be exposed. It will be met with either within, or upon, the carotid sheath over the line of the common carotid artery, and in connection with it the loop known as the ansa cervicis (hypoglossi) is to be exposed. It is situated about the centre of the neck, and taking part in it there will be found, coming from behind, a nerve formed by the union of the two rami communicantes cervicis (hypoglossi) from the second and third cervical nerves. These two rami, however, may join the descendens cervicis separately, and before receiving them it parts with its branch to the anterior belly of the omo-hyoid. The loop itself is to be shown furnishing branches to the sterno-hyoid, sterno-thyroid, and posterior belly of the omo-hyoid. The thyro-hyoid muscle is also to be dissected, and the thyro-hyoid branch of the hypoglossal nerve is to be shown entering the muscle beneath its posterior border. Passing beneath this border there will also be found the internal laryngeal nerve and superior laryngeal artery, which here pierce the thyro-hyoid membrane on their way to the interior of the larynx.

The structures along the median line of the neck are to be carefully dissected at this stage, in connection with the operations of laryngotomy and tracheotomy. In doing so the disposition of the deep cervical fascia must be constantly kept in view, and the following groups of lymphatic glands may as well be disposed of at once, namely, the submaxillary lymphatic

glands, the suprahyoid or submental glands, and the prelaryngeal glands, the latter being met with in the vicinity of the cricoid cartilage, but being sometimes absent. The structures to be attended to along the median line of the neck are as follows, in order from above downwards: (1) the submental triangle; (2) the body of the hyoid bone, with the great cornu on either side; (3) the thyro-hyoid membrane; (4) the isthmus (pomum Adami) of the thyroid cartilage, above which is the well-marked V-shaped thyroid notch, whilst on either side of it is the expanded ala of the thyroid cartilage; (5) the crico-thyroid membrane, largely concealed on either side by the crico-thyroid muscle, and crossed at its centre by the crico-thyroid arterial arch; (6) the narrow anterior part of the cricoid cartilage; (7) the trachea; (8) the isthmus of the thyroid body, usually lying upon the second and third tracheal rings; and (9) the inferior thyroid plexus of veins, from which there pass downwards the right and left inferior thyroid veins. The superficial muscular relations of the trachea are to be carefully noted. The region concerned in laryngotomy is that occupied by the crico-thyroid membrane. The high operation of tracheotomy affects the trachea above the isthmus of the thyroid body, and the low operation is performed upon the trachea below the isthmus. In connection with the latter part of the trachea the dissector should carefully note the following points: (1) its gradually increasing depth; (2) the presence of the inferior thyroid plexus of veins; (3) the relation to it of the innominate and right common carotid arteries; and (4) the possible presence of an arteria thyroidea ima at or close to the median line.

The carotid sheath is next to be dissected, keeping in view that the descendens cervicis (hypoglossi) nerve may lie upon it, or be within it. The sheath will be found to be derived from the posterior lamina of the sheath of the sterno-cleido-mastoid muscle. It is to be carefully opened, having previously noted the sterno-cleido-mastoid artery, and its contents displayed, namely, the common carotid artery, the internal jugular vein, and the pneumogastric nerve, all in separate compartments. Possibly the descendens cervicis nerve may be within it. The contents of the sheath are to be fully dissected, bearing in mind that the gangliated cord of the sympathetic lies close behind the sheath. In dissecting the internal jugular vein the superior and middle thyroid veins are to be borne in mind as tributaries of it, and the deep cervical glands will be found more or less along its course. An effort should be made to expose the carotid body, which will be found behind the common carotid artery close to its bifurcation. On a level with the thyroid attachment of the thyro-hyoid muscle the external laryngeal nerve will be found, which is to be traced downwards to its distribution, chiefly to the crico-thyroid muscle.

The digastric muscle is next to be dissected, along with the stylo-hyoid muscle, which lies above its posterior belly, and the hypoglossal nerve, which lies along its lower border, and here gives off the descendens cervicis and thyro-hyoid nerves. In connection with the V-shaped arrangement of the tendon of the digastric and the hypoglossal nerve, which has now passed beneath the digastric tendon, the triangle of Lesser is to be carefully studied. It contains a portion of the lingual artery, lying under cover of the hyo-glossus muscle. The three subdivisions of the anterior triangle of the neck are now to be reviewed, namely, the muscular (inferior carotid), carotid (superior carotid), and digastric or submaxillary triangles, and their contents noted. The first parts of the external and internal carotid arteries are to be dissected, the former as high as the point where it enters the parotid gland. The anterior branches of the external carotid are to be displayed, namely, the superior thyroid, lingual, and facial, in this order from below upwards. The superior thyroid artery is to be completely dissected, and the following branches of it are to be specially noted, namely, the crico-thyroid artery, and the artery of the isthmus of the thyroid body. The facial artery is only to be dissected as far as the base of the inferior maxilla. Its relation to the submaxillary gland is to be noted, and its cervical branches shown, namely, inferior palatine, tonsillar, glandular, and submental. The lingual artery is, meanwhile, only to be dissected at its origin, and in the first part of its course.

During the present stage of the dissection the facial vein is to be kept in view; its union with the anterior division of the temporo-maxillary vein to form the common facial vein is to be shown; and the ending of the common facial vein and of the lingual veins in the internal jugular are to be displayed.

The posterior branches of the external carotid, namely, the occipital and the posterior auricular, are also to be fully dissected, and as many of their branches as possible shown. The ascending pharyngeal branch of the external carotid artery is placed too deeply for complete dissection at this stage, but the dissector should bear in mind that it arises from the deep surface of the external carotid near its commencement, and he may expose it by separating the external and internal carotid arteries. The terminal branches of the external carotid, namely, the superficial temporal and the internal maxillary, will be dissected at a later stage in connection with the parotid gland.

At this stage the dissector should direct his attention to the thyroid body. This should be dissected with the greatest care, its lateral lobes and isthmus being clearly defined, together with their blood-supply, the inferior thyroid artery reaching the lateral lobe from below. The not infrequent presence of a pyramidal or middle lobe is to be borne in mind, and in connection with it the fibrous band and levator glandulæ thyroideæ muscle, which pass from its apex to the body of the hyoid bone. When present, it usually springs from the upper border of the isthmus close to the left lobe. The disposition of the thyroid veins is to be noted. The cervical parts of the trachea and œsophagus are also to be fully dissected. The manner in, and the extent to, which the œsophagus projects to the left of the trachea at the root of the neck is to be specially noted, and the inferior or recurrent laryngeal nerve and inferior laryngeal artery are to be carefully displayed as they ascend in the groove between the trachea and œsophagus.

Root of the Neck.—The deep dissection of the root of the neck is now to be overtaken. The scalene muscles—anticus, medius, and posticus—are to be dissected, and their relations are to be carefully noted, more especially those of the scalenus anticus, in connection with which the scalene tubercle or spine (Lisfranc's tubercle) on the inner border of the first rib is to be examined. The first part of the subclavian artery is to be dissected, and its relations mastered. The junction of the internal jugular and subclavian veins to form the innominate vein on either side is to be shown. Opening into the angle of junction of these two veins on the right side the short right lymphatic duct is to be looked for, and on the left side the thoracic duct, the latter arching outwards, forwards, and downwards. The left subclavian artery and the left common carotid at the root of the neck are to be contrasted with the corresponding vessels of the right side, and the differences noted, not only as regards their origins, but also as regards their relations. The right pneumogastric nerve is to be shown crossing the first part of the right subclavian artery, and parting with its recurrent laryngeal branch opposite the lower border of the vessel, that branch turning up behind the artery. The left pneumogastric nerve will be found parallel with the first part of the left subclavian artery, its recurrent laryngeal branch having been given off within the thorax, opposite the lower border of the arch of the aorta. The recurrent laryngeal nerve on either side is then to be followed upwards in the groove between the trachea and œsophagus, in company with the inferior laryngeal artery. The sympathetic loop, known as the ansa Vieussenii, is to be shown in connection with the first part of the subclavian artery, and the sympathetic cord will be found behind it. The branches of this part of the vessel are now to be dissected. The vertebral artery is to be dissected in the first part of its course, and the inferior cervical ganglion of the sympathetic, which lies behind it, is to be kept in view. The mode of termination of the vertebral vein is to be shown. The internal mammary artery is to be followed downwards as far as its entrance upon its thoracic course, and the phrenic nerve is to be shown crossing it superficially from without inwards. The thyroid axis is next to receive attention, and its three branches, namely, inferior thyroid, transverse cervical, and suprascapular,

are to be dissected. The tortuous course of the inferior thyroid artery inwards behind the lower part of the carotid sheath is to be noted, and its ascending cervical branch is to be shown. The proximity of the middle cervical ganglion of the sympathetic to the artery is to be borne in mind. The suprascapular artery is to be followed outwards, and its medullary branch to the clavicle is to be looked for. The transverse cervical artery, like the suprascapular, above which it lies, is to be followed outwards. The suprascapular and transverse cervical have been in part previously dissected.

The second part of the subclavian artery is to be exposed by dividing and reflecting the scalenus anticus muscle, behind which it lies, whilst the subclavian vein lies in front of that muscle. At this stage the mode of formation of the brachial plexus, and the relations of its nerve-trunks to the subclavian artery are to be revised. The only branch from the second part of the subclavian artery to be dissected is the superior intercostal artery, which, however, usually arises from the first part of the artery on the left side. To see this vessel on the right side it will be necessary to draw the second part of the subclavian artery well forwards and downwards, because the superior intercostal arises from its posterior and upper aspect. Thereafter the vessel descends in front of the neck of the first rib to supply the first and second intercostal spaces, but, before it does so, the deep cervical artery is to be shown arising from it, and taking a backward course between the seventh cervical transverse process and the neck of the first rib. In an earlier stage of the dissection this vessel has been seen ascending upon the semispinalis colli muscle, under cover of the complexus, and anastomosing with the ramus princeps cervicis of the occipital from the external carotid.

The apex of the lung, covered by the dome of the pleura, is to be very carefully noted, and attention is to be given to Sibson's fascia. This fascia will be found to extend from the front of the transverse process of the seventh cervical vertebra to the inner border of the first rib.

Suprahyoid Region.—The dissection of the digastric or submaxillary triangle is now to be overtaken in so far as it can be prior to section of the mandible. The superficial part of the submaxillary gland, of considerable bulk, will first receive attention. Passing downwards over it the dissector will find the facial vein, and more or less embedded in its upper and outer part he will find the facial artery on its way to the face. The superficial part of the gland is to be turned outwards, and kept out of the way by hooks. Thereafter the mylo-hyoid muscle is to be dissected, along with the mylo-hyoid nerve and submental artery resting upon it. The distribution of the mylo-hyoid nerve to the mylo-hyoid muscle and anterior belly of the digastric is to be clearly shown, and the median raphé between the two mylo-hyoid muscles is to be made evident. The posterior border of the mylo-hyoid muscle is next to receive attention. Passing beneath this border will be found, in order from below upwards, the hypoglossal nerve, the deep part of the submaxillary gland, and the lingual (gustatory) nerve. In the back part of the digastric triangle a portion of the parotid gland will be met with, which is separated from the submaxillary gland by the process of the deep cervical fascia known as the stylo-maxillary ligament.

Structures beneath the Mylo-hyoid Muscle.—To expose these structures requires very careful dissection. The mylo-hyoid muscle is to be separated from its fellow along the median raphé, care being taken not to injure the genio-hyoid muscle. It is also to be detached from the body of the hyoid bone, and then the entire muscle is to be reflected upwards towards the mandible. The subsequent steps of this dissection will no doubt be simplified at a later stage when it is in the power of the dissector to divide the mandible at certain points, but no definite hard-and-fast lines can be laid down at this stage. After reflection of the mylo-hyoid muscle the hyo-glossus will be exposed, as well as the stylo-glossus and genio-hyoid. The hyo-glossus is the dissector's landmark. Resting upon its surface he will find the following structures: (1) the hypoglossal nerve, along with the ranine vein, lying close to the hyoid bone; (2) the deep part of the submaxillary gland and Wharton's duct, lying above the hypoglossal nerve; and (3) the lingual nerve, highest

of all. Between the lingual nerve and the deep part of the submaxillary gland he will, without much difficulty, be able to display the submaxillary ganglion, and show its connections and the branches proceeding from it.

In front of the hyo-glossus muscle the genio-hyo-glossus will be seen, and resting upon it the dissector will find the sublingual gland, to which he should give his attention. The genio-hyo-glossus cannot be dissected in full until the mandible has been divided, and the tongue put upon the stretch by tying its tip to the point of the nose. The following structures passing beneath the posterior border of the hyo-glossus muscle are to be shown, in the following order from above downwards: (1) the glosso-pharyngeal nerve; (2) the stylo-hyoid ligament; and (3) the lingual artery.

The Face.—In the dissection of the face the dissectors of the head should, if possible, dissect in concert. The muscles of expression should be shown upon one side, together with the chief nerves and vessels. On the other side a detailed dissection of all the nerves and vessels is to be made, which will involve the division of certain of the muscles. The frontal and temporal regions having been previously dissected, the skin is to be removed from the face in an outward direction, for which purpose a median incision is to be made from the root of the nose downwards to the symphysis of the inferior maxilla. This incision is to embrace the nostril and one half of the oral aperture. The reflection of the skin will be facilitated by making one or more transverse incisions at the option of the dissector. An incision should also be made around the orbit. The structures already dissected in the frontal and temporal regions are to be revised. The orbicularis palpebrarum is to be dissected by removing the skin very carefully from it in a direction from the circumference to the ciliary margin of each eyelid, along which the skin is to be cut. At the inner canthus the tendo palpebrarum or internal tarsal ligament is to be displayed, and its relation to the lachrymal sac noted. The corrugator supercilii is to be looked for arising from the inner end of the superciliary ridge, and passing outwards and upwards under cover of the frontalis.

The pyramidalis nasi admits of easy dissection as it ascends from the aponeurosis of the compressor naris over the nasal bone to the skin over the glabella. The muscles between the eye, side of the nose, and upper lip are next to be dissected, such as the compressor naris, levator labii superioris alæque nasi, levator labii superioris, depressor alæ nasi, dilator naris anterior, dilator naris posterior, levator anguli oris, and the two zygomatic muscles, major and minor. The risorius of Santorini and the buccinator next fall to be dissected, and in connection with the latter muscle the buccal pad of fat is to receive attention, as well as the buccal lymphatic glands. The muscles between the lower lip and the inferior maxilla come next in order, these being the depressor anguli oris, depressor labii inferioris, and levator menti. The last muscle is most easily shown by (1) everting the lower lip and dividing the mucous membrane in the region of the incisor fossa of the inferior maxilla; and (2) dividing the skin at the median line close down to the bone, but leaving the lower lip uncut. The dissection of the orbicularis oris requires great care. The lips should be well everted, and maintained in this position. The dissector is then to remove the mucous membrane, when the labial mucous glands will be exposed. The deepest stratum of the orbicularis oris is then to be dissected, and an effort made to expose the special muscles which compose it, namely, (1) the musculus incisivus superior, coming from the incisor fossa of the superior maxilla; (2) the musculus naso-labialis, coming from the back part of the nasal septum; and (3) the musculus incisivus inferior, coming from the incisor fossa of the inferior maxilla. The lips being replaced in position, the superficial stratum of the orbicularis oris is to be examined. It will be found to be composed of fibres derived from the elevators and depressors of the angles of the mouth and lips, these fibres stopping at the median line of each lip. The intermediate stratum of the muscle will be seen to consist of buccinator fibres, those of opposite sides being directly continuous at the median line.

The nerves of the face are now to be fully dissected. **The supra-orbital,**

the supratrochlear, the temporal branch of the orbital or temporo-malar, and the auriculo-temporal have been already dissected. The numerous branches of the temporo-facial and cervico-facial divisions of the facial nerve are to be followed from the parotid gland to their distribution, care being taken to note that the facial is the motor nerve of the buccinator muscle. The infratrochlear branch of the nasal nerve is to be met with in the region of the inner canthus, where it emerges from the orbit below the pulley of the superior oblique muscle. The external terminal branch of the nasal nerve will be found emerging between the lower border of the nasal bone and the upper lateral nasal cartilage, after which it descends beneath the compressor naris muscle to the tip of the nose. The infra-orbital nerve will be found emerging through the infra-orbital foramen, but to display this nerve it is necessary to divide the levator labii superioris muscle. Under cover of this muscle the nerve communicates with the infra-orbital branches of the facial to form the infra-orbital plexus. The inferior palpebral, nasal, and superior labial branches of the infra-orbital nerve are to be followed out. The malar branch of the orbital or temporo-malar nerve will be found emerging through the malar foramen in the malar bone. The long buccal nerve emerges from beneath the anterior border of the masseter on to the buccinator, where its branches communicate with the buccal branches of the facial nerve to form the buccal plexus. The facial branches of the great auricular nerve ramify in the integument over the parotid gland, and send offsets into the gland. The mental nerve will be found emerging through the mental foramen in the inferior maxilla, where it is under cover of the depressor anguli oris, and in line with the interval between the two lower bicuspid alveoli.

The chief arteries to be dissected are the facial and transverse facial. The facial artery is easily found, and is to be followed from the base of the inferior maxilla to the region of the inner canthus. As many of its branches as possible are to be shown, more particularly the two coronary arteries. The position of the facial vein on the outer side of the artery upon the body of the inferior maxilla, in front of the masseter, is to be noted, and a lymphatic gland is to be looked for in this situation. The facial vein will be found to receive a fairly large tributary, the deep facial vein, which comes from the pterygoid plexus, and emerges from behind the anterior border of the ramus of the inferior maxilla and of the masseter muscle. The transverse facial artery will be met with emerging from the anterior border of the parotid gland, after which it crosses the masseter immediately above Stensen's duct. The infra-orbital and mental arteries admit of easy dissection, The other arteries, though numerous, are for the most part of small size, and for them the dissector is referred to the description given of them in the text.

The parotid gland is to be carefully dissected, and all its relations displayed. The strong capsule which invests it, and which is derived from the deep cervical fascia, is to be noted. The lower part of the gland is to be shown occupying the back part of the digastric triangle, where it is separated from the submaxillary gland by the stylo-maxillary ligament. Upon the gland, but beneath the parotid fascia (anterior wall of the capsule), and also within the gland, will be found the parotid lymphatic glands. Emerging from the anterior border of the gland, and passing forwards over the masseter muscle on to the buccinator, the parotid or Stensen's duct is to be shown, with the transverse facial artery above it, and the infra-orbital branches of the facial nerve below it. The pars or glandula socia parotidis is to be shown accompanying Stensen's duct for a variable distance, and lying above it. The branches of the facial nerve are now to be followed into the parotid gland, cutting away the glandular substance in doing so. This will enable the dissector to trace the trunk of the facial nerve to the stylo-mastoid foramen, and to show its posterior auricular, digastric, and stylo-hyoid branches. The auriculo-temporal nerve is also to be shown within the upper part of the gland, and communications between this nerve and the temporo-facial division of the facial, as well as between the great auricular nerve and the cervico-facial division of the facial, are to be kept in view. The external

carotid artery is to be shown within the gland, dividing into its superficial temporal and internal maxillary branches. The superficial temporal vein is to be followed downwards within the gland until it is joined by the internal maxillary vein, and the resultant vessel, namely, the temporo-maxillary vein, is thereafter to be followed downwards within the gland in front of the external carotid artery. The mode of termination of the temporo-maxillary vein is also to be shown, its anterior division joining the facial vein to form the common facial vein, and its posterior division joining the posterior auricular vein to form the external jugular vein. The foregoing dissections will have led to the removal of a large part of the parotid gland. The dissector will therefore be able to see that it extends inwards behind the ramus of the inferior maxilla, and deeply into the posterior part of the glenoid fossa of the temporal bone.

Ocular Appendages.—The eyelids or palpebræ, with their tarsal plates, are to receive attention, as well as the eyelashes or cilia, and the canthi, outer and inner. At the inner canthus the lacus lacrimalis, caruncula lacrimalis, and plica semilunaris are to be studied, as are also the papillæ lacrimales and puncta lacrimalia. The lachrymal canaliculi are to be opened up, and the lachrymal sac is to be shown lying in the lachrymal groove of the lachrymal bone and nasal process of the superior maxilla. The sac should be laid open, and a probe passed down the nasal duct. The superior and inferior palpebral ligaments, as well as the external tarsal ligament, are to be dissected. The internal tarsal ligament or tendo palpebrarum has been already seen. The conjunctiva, palpebral and ocular, is to be carefully studied, and the superior and inferior fornix noted. On the internal surface of each tarsal plate, between it and the conjunctiva, the outlines of the Meibomian glands will be seen, and their orifices may be visible, arranged in a row a little behind each ciliary margin. In this situation the glands of Moll are to be borne in mind.

Auricle (Pinna).—The auricle is to be carefully studied and dissected. Its extrinsic muscles, namely, attrahens, attollens, and retrahens, auriculam have been already attended to. The component parts of the auricle are to be mastered, namely, the concha, helix, crus helicis, antihelix, tragus, antitragus, incisura intertragica, lobule, tubercle of Darwin, fossa of the helix (scaphoid fossa), and fossa of the antihelix (triangular fossa). The ligaments and intrinsic muscles are to be dissected, according to the description of them which is given in the text; the blood-supply and nerve-supply of the auricle are to be reviewed; and thereafter an effort is to be made to dissect the plate of yellow elastic fibro-cartilage which forms its framework. The meatus auditorius externus is to receive very careful study.

Nose.—The cartilaginous framework of the nose is now to be dissected, and this should be overtaken by the two dissectors working in concert. The upper lateral nasal cartilages will be found immediately below the nasal bones. The lower lateral nasal cartilages, or cartilages of the apertures, are situated below the preceding, and each is bent so as to lie in front, and on each side, of the nostril. The crus laterale and crus mediale of each cartilage of the aperture are to be noted. Two or more sesamoid, or minor, cartilages are to be looked for in the fibrous tissue which connects the crus laterale to the superior maxilla. In dissecting the foregoing cartilages the dissectors should have before them the description given of them in the text. The cartilage of the septum is mesially placed, and can only be fully studied in connection with the interior of the nasal fossæ. It is sufficient meanwhile to note that its anterior border is visible between the anterior borders of the upper lateral nasal cartilages inferiorly.

Masseter Muscle.—Before leaving the dissection of the face the masseter is to be dissected. Its superficial and deep parts are to be clearly shown, and its relations thoroughly mastered.

Orbit.—To prepare the cavity of the orbit for dissection the osseous roof must be removed. For this purpose a vertical cut is to be made with the saw through the frontal bone as low as a point just external to the fovea trochlearis. A second cut is to be made with the saw through the lateral wall of the skull from a point on a level with the auricle downwards and

forwards to the sphenoidal fissure. A large portion of the malar bone is to be removed, for which purpose the bone-pliers may suffice. In his further mode of procedure the dissector should be careful to leave intact the portion of bone immediately surrounding the optic foramen. The inner and outer saw-cuts are to be connected by using the chisel and mallet, one or two smart knocks being sufficient for this purpose. Thereafter the osseous roof of the orbit is to be tilted forwards by a smart knock with the mallet. The small wing of the sphenoid bone is next to be removed with the bone-pliers. In the foregoing manner the cavity of the orbit will be exposed, and the sphenoidal fissure will be opened from above.

The periosteum of the orbit is to be examined, and then laid open. Exactly in the median line, and embedded in the soft fat of the orbit, the dissector will find the frontal nerve, which anteriorly is accompanied by the supra-orbital artery, and divides into supra-orbital and supra-trochlear. The supratrochlear nerve, before leaving the orbit, will be found to give off a small twig, which descends to form a loop with the infratrochlear branch of the nasal nerve. More deeply placed than the frontal nerve, but also in the median line, the levator palpebræ superioris muscle is to be dissected, and immediately beneath it the superior rectus. The branches of the upper division of the third or oculo-motor nerve to these two muscles are to be found entering the deep or ocular surface of each muscle.

The superior oblique muscle is to be dissected along the inner wall of the orbit, where it lies superficially, and the dissector is to show the fourth nerve entering its superficial or orbital surface far back. The muscle is to be followed forwards, and its tendon traced through the trochlea or pulley, and thereafter to its insertion. Underneath the superior oblique muscle will be found the internal rectus, in dissecting which the branch from the lower division of the third nerve is to be shown entering its deep or ocular surface. Between the superior oblique and internal rectus muscles will be found the nasal nerve and the anterior and posterior ethmoidal vessels. The lachrymal gland will be found at the anterior and outer part of the orbit. The lachrymal nerve, accompanied by the lachrymal artery, is to be found along the outer wall of the orbit, and is to be followed forwards to its distribution. A branch is to be looked for passing downwards from the lachrymal nerve to join the temporal branch of the orbital or temporo-malar nerve. Beneath this nerve the dissector will find the external rectus muscle.

The frontal nerve and levator palpebræ superioris are to be divided, and to facilitate the dissection of the ocular muscles the eyeball may be inflated. This must be done with very great care, in order to leave intact important structures not yet dissected. The optic nerve is to be exposed by carefully pushing aside the yielding structures which cover it. Having slipped a ligature round the nerve not far from the eyeball, a puncture is to be made in the nerve behind the ligature, and a blow-pipe is to be pushed into the nerve as far as its centre. The blow-pipe is then to be pushed forwards into the eyeball, and when the eyeball has been inflated through it the pipe is to be withdrawn, and the ligature made fast. It is possible to destroy the ciliary ganglion in inflating the eyeball, but that ganglion could easily be dissected on the outer side of the optic nerve before taking the steps necessary for inflation.

In the dissection of the ocular muscles the capsule of Tenon is to be kept in view. It forms a connective-tissue covering for the sclerotic coat of the eyeball, and extends from the point of entrance of the optic nerve to near the margin of the cornea, where it joins the ocular conjunctiva. Between the capsule of Tenon and the sclerotic a space can easily be demonstrated by puncturing the capsule, and introducing the handle of a scalpel. This is the perisclerotic space, or Tenon's space. The suspensory ligament of Lockwood requires great care in dissection. It is a thickening of the lower part of Tenon's capsule, and extends between the malar and lachrymal bones. The capsule of Tenon is pierced by the ocular muscles, to which it furnishes sheaths.

In connection with the sheaths of the recti muscles important forward

expansions are to be noted. Those which are connected with the external and internal recti are strong, and are attached, respectively, to the orbital process of the malar bone and to the lachrymal crest of the lachrymal bone. The expansion connected with the superior rectus blends with the deep layer of the tendon of the levator palpebræ superioris, and that which is connected with the inferior rectus passes to the inferior tarsal plate.

The external rectus muscle is to be fully exposed, with the sixth nerve entering its deep or ocular surface. The two heads of the muscle are to be made quite evident, with the following structures passing between them, in order from above downwards: (1) the upper division of the third nerve, (2) the nasal nerve, (3) the lower division of the third nerve, (4) the sixth nerve, and (5) the ophthalmic vein or veins.

The superior rectus is to be divided and thrown forwards and backwards. On pushing aside and removing a quantity of fat the optic nerve will be exposed, and crossing it from without inwards is the ophthalmic artery. An effort should be made to show the numerous branches of this artery as detailed in the text. The nasal nerve is to be shown crossing the optic nerve from without inwards to the anterior ethmoidal canal, through which it leaves the orbit. The branches of the nerve to be looked for are as follows: (1) the long or sensory root of the ciliary ganglion, which arises from the nasal as it passes between the two heads of the external rectus; (2) two long ciliary nerves, which communicate with the short ciliary nerves, and accompany them; and (3) the infratrochlear nerve. The latter nerve is given off by the nasal at the anterior ethmoidal foramen, and it is to be followed forwards to near the pulley of the superior oblique, where it receives a twig from the supratrochlear nerve. Thereafter it passes beneath the pulley, and emerges from the orbit at the inner canthus. The ciliary or lenticular ganglion will be found on the outer side of the optic nerve. Its long or sensory root will be found coming from the nasal nerve, and its sympathetic root, from the cavernous plexus, usually reaches it through the sensory root. Its short or motor root comes from that branch of the lower division of the third nerve which supplies the inferior oblique muscle. Passing forwards from the ganglion are the short ciliary nerves, which will be seen to range themselves above and below the optic nerve, by which they are conducted to the back part of the sclerotic. The third cranial nerve is to be fully dissected. Its upper and lower divisions are to be shown, and the distribution of their branches made evident, those of the upper division supplying the levator palpebræ superioris and the superior rectus, and those of the lower division supplying the internal rectus, inferior rectus, and inferior oblique. The motor root of the ciliary ganglion comes from the branch to the last-named muscle. The dissector is to note that the branches of the third nerve enter the muscles which they supply on their deep or ocular surface, except in the case of the branch to the inferior oblique, which enters the posterior border of that muscle.

In connection with the origins of the recti muscles the fibrous ring in the region of the optic foramen is to be examined; and its upper part, or superior tendon of Lockwood, and lower part, or ligament of Zinn, are to be noted.

The inferior oblique muscle is situated below the eyeball and also on its outer aspect. In order to expose this muscle the lower eyelid is to be everted, and the conjunctiva divided along the inferior fornix or line of reflection from the lower eyelid on to the eyeball. The origin of the muscle will be found at the anterior and inner part of the floor of the orbit, immediately external to the opening of the lachrymal canal.

The orbital or temporo-malar nerve, which enters the orbit through the spheno-maxillary fissure, is to be looked for in two divisions—temporal and malar. The temporal branch receives a communicating twig from the lachrymal nerve, and ascends upon the outer wall of the orbit to the temporal canal. The malar branch passes forwards in the angle between the outer wall and floor to the malar canal.

During the dissection of the orbit the ophthalmic artery and its branches, as well as the ophthalmic vein or veins, are to be kept in view.

The structures which pass through the sphenoidal fissure are next to be carefully dissected, and their relative positions noted.

Pterygo-maxillary Region.—The temporal fascia and the part of the temporal muscle above the zygomatic arch have been already dissected. The masseter muscle has also been dissected. In order to expose the pterygo-maxillary region the dissector must proceed in a definite order. The zygomatic arch is to be divided in front of, and behind, the origin of the masseter. This is to be done at first with the saw and then with the bone-pliers. The zygomatic arch, bearing the origin of the masseter, is to be turned downwards until the sigmoid notch of the inferior maxilla is exposed. At this stage the dissector is to show the masseteric nerve and artery emerging from the pterygo-maxillary region over the sigmoid notch and entering the deep surface of the masseter. The nerve and artery having been divided, the masseter is to be stripped from the outer surface of the ramus of the inferior maxilla as low as the angle of the bone. The extensive fleshy origin of the deep part of the muscle from the inner surface of the zygomatic arch is to be carefully noted. The dissector is next to turn his attention to the insertion of the temporal muscle, noting how it extends downwards within the anterior border of the mandibular ramus to the region of the third molar alveolus. The long buccal nerve and the buccal artery are to be caught just within the anterior border of the mandibular ramus as they pass forwards and downwards, or, at all events, they are to be separated from the deep aspect of the insertion of the temporal muscle by pressure with the handle of the scalpel. The coronoid process of the mandible is then to be got rid of by means of the saw and bone-pliers in the following manner : (1) make a vertical cut from the centre of the sigmoid notch downwards for fully $\frac{1}{2}$ inch ; and (2) make a horizontal cut from the anterior border of the mandibular ramus backwards to meet the vertical cut at a right angle. In addition to these cuts through the bone, the strongly tendinous fibres of the temporal muscle must also be divided. The coronoid process, bearing part of the insertion of the temporal muscle, is then to be turned upwards, and the muscle is to be stripped gradually from the lower part of the floor of the temporal fossa. The deep temporal nerves, three in number, are to be looked for, as well as the anterior and posterior deep temporal arteries. An effort should also be made to expose the middle temporal artery, which, being a branch of the superficial temporal, has had to pierce the temporal fascia and temporal muscle to reach the temporal fossa. This artery ascends in the groove familiar to the dissector as marking the outer surface of the squamous part of the temporal bone.

Two other horizontal cuts with the saw and bone-pliers still require to be made through the mandibular ramus. One is to be made immediately below the neck of the inferior maxilla, thus leaving intact the insertion of the external pterygoid muscle. The other cut is to be made across the ramus from its anterior to its posterior border on a level with the summit of the crown of the third or last molar tooth, or, if this tooth be absent, as near that level as possible. This will keep the dissector free of the inferior dental foramen on the inner surface of the ramus, and will consequently leave intact the inferior dental nerve and artery.

The structures to be dissected in connection with the pterygo-maxillary region are as follows : (1) the external and internal pterygoid muscles, the former passing horizontally to the front of the neck of the inferior maxilla, and the latter extending downwards and outwards to the inner surface of the mandibular ramus between the inferior dental foramen and the angle of the bone ; (2) the first and second parts of the internal maxillary artery, the second part of the vessel usually lying upon the external pterygoid muscle, but sometimes passing beneath it ; (3) the pterygoid plexus of veins around the external pterygoid muscle ; (4) the spheno-mandibular ligament (internal lateral ligament of the temporo-mandibular joint), emerging from beneath the external pterygoid muscle and resting upon the internal pterygoid ; (5) the inferior dental and lingual nerves, emerging from beneath the lower border of the external pterygoid and passing downwards, the former, which is posterior in position, parting with its mylo-hyoid branch close to

the inferior dental foramen ; (6) the long buccal nerve emerging between the two heads of the external pterygoid, and giving upwards the anterior deep temporal nerve ; and (7) the middle deep temporal nerve and the masseteric nerve, emerging from beneath the upper border of the external pterygoid, the latter parting with the posterior deep temporal nerve.

The first and second parts of the internal maxillary artery are to be dissected, as are also the pterygoid muscles. In dissecting the artery the internal maxillary lymphatic glands are to be borne in mind. The first part of the artery will be found to give off (1) the deep auricular, (2) the tympanic, (3) the middle meningeal, furnishing the small meningeal, and (4) the inferior dental, giving off its mylo-hyoid branch. The second part gives off masseteric, deep temporal (anterior and posterior), pterygoid, and buccal branches. The posterior dental artery will be found coming off from the vessel as it is about to enter the spheno-maxillary fossa. The third part of the artery must be deferred to the time when the spheno-maxillary fossa is being dissected.

The inferior dental (with its mylo-hyoid branch) and lingual nerves having been dissected *in situ*, the inferior dental canal is to be laid open, and the inferior dental nerve fully dissected to its distribution. In opening the canal the saw, chisel and mallet, and bone-pliers are to be used. This dissection will show the dissector how the pulps of the lower teeth are supplied with nerves, and it will also make evident the origin of the mental nerve at the level of the mental foramen.

Before reflecting the external pterygoid muscle certain details may be looked to in connection with the temporo-mandibular joint. A complete dissection, however, of this articulation can only be made at the sacrifice of other structures. The dissector is therefore recommended to perform this dissection upon a specially reserved part. He should have little difficulty in studying the external lateral ligament and the capsule. The capsule is to be opened and the interarticular fibro-cartilage noted. This will at once make evident the existence of two synovial membranes, upper and lower. Beyond this the dissector can hardly go, but he should read the description which is given of this joint in the text.

The mandibular condyle is now to be disarticulated and turned forwards, along with the interarticular fibro-cartilage. In this manner the external pterygoid muscle will be reflected ; but, in disarticulating the condyle, the dissector should keep a sharp look-out for the auriculo-temporal nerve, which is in intimate contact with the back of the temporo-mandibular joint. The reflection of the external pterygoid muscle will enable the dissector to expose the following structures : (1) the inferior maxillary division of the fifth cranial nerve and its branches ; (2) the otic (Arnold's) ganglion ; (3) the chorda tympani nerve, passing forwards and downwards, and applying itself to the lingual nerve at an acute angle ; (4) the middle meningeal artery, parting, as a rule, with the small meningeal ; and (5) the upper part of the spheno-mandibular ligament.

The middle meningeal artery will be found to pass, as a rule, between the two roots of origin of the auriculo-temporal nerve. The foregoing structures are to be dissected, as nearly as possible, in agreement with the description which has been given of them in the text. Admittedly the dissector will find the otic ganglion extremely difficult of dissection, but he should not refrain from attempting it. The ganglion lies behind the undivided trunk of the inferior maxillary nerve close to the foramen ovale, and the best plan is to trace upwards the internal pterygoid nerve, with which the ganglion is closely connected.

The pterygo-mandibular ligament is to be examined, which separates the buccinator and superior constrictor muscles, giving origin to fibres of both muscles.

Sublingual Region.—The structures in the submaxillary region have been previously dissected, *e.g.*, the mylo-hyoid muscle, the structures covered by it, the genio-hyoid, and the hyo-glossus. This being so, the dissector is advised to saw through the inferior maxilla, say between the lateral incisor and canine alveoli. This should also be done on the other side by his partner,

because at this stage it is most desirable that the two dissectors should work in concert. The foregoing cuts will isolate the symphysial portion of the inferior maxilla, and so preserve the attachments of the anterior belly of the digastric, genio-hyoid, and genio-hyo-glossus muscles. By a few touches of the knife the mucous membrane on the inner surface of the mandible can be cut. Thereafter a needle, threaded with a ligature, is to be pushed through the tip of the tongue and through the tip (or columella) of the nose. The needle having now been dispensed with, the ends of the ligature are to be tightly drawn and fixed. The object in this procedure will be at once obvious to the dissector, namely, to put the tongue as much upon the stretch as possible. In the further stages of this dissection the ligature can easily be undone so as to allow the tongue to retire to its normal position. The dissector will now recognise structures which he has been advised to dissect partially at a previous stage. The structures covered by the mylo-hyoid muscle are now to be completely dissected and mastered, namely, (1) the lingual nerve, with the submaxillary ganglion; (2) the deep part of the submaxillary gland and Wharton's duct; (3) the hypoglossal nerve; and (4) the sublingual gland, for the ducts of which the dissector is referred to the text. The genio-hyoglossus muscle now admits of complete dissection, and it will well repay the dissector to study it fully. Immediately external to its extensive insertion into the side of the tongue he should expose the tortuous ranine artery. The genio-hyoid and hyo-glossus muscles have been already referred to. This region is admittedly one of extreme complication and perplexity, so that the dissector should not be surprised that no hard-and-fast instructions can be submitted for his guidance. He may, however, show the stylo-hyoid ligament, the stylo-glossus muscle (already referred to at an earlier stage), the stylo-pharyngeus muscle, and, in connection with that muscle, the glosso-pharyngeal nerve.

The hyo-glossus muscle is to be divided near its origin and reflected towards the tongue. This will expose a portion of the lingual artery, which is now to receive the attention of the dissector, and may be fully studied with advantage. The branches of the vessel are to be dissected in accordance with the text, and special attention is to be directed to the ranine artery.

Superior Maxillary Nerve, Meckel's Ganglion, and Third Part of Internal Maxillary Artery.—This dissection is one of considerable difficulty, and the dissector is advised to have before him for his guidance a section of the skull bearing upon this region. The contents of the orbit having been entirely removed, the skull is to be sawn through in a direction downwards and forwards from a point above the meatus auditorius externus to the region of the inner end of the sphenoidal fissure. This cut will pass through the squamous part of the temporal bone and the great wing of the sphenoid. A second cut with the saw is to be made in advance of the preceding, on a level with the anterior border of the great wing of the sphenoid, and this is to meet the first cut. The portion of bone included between these two cuts is to be removed. The foramen rotundum is to be carefully laid open with the bone-pliers, and the infra-orbital canal is to be opened with equal care. To open the posterior part of this canal the bone-pliers will be sufficient, but the anterior part of the canal, being somewhat deeply placed, will require the saw, or the chisel and mallet. The superior maxillary nerve is now to be studied, its straight course forwards through the foramen rotundum, upper part of the spheno-maxillary fossa, infra-orbital canal and infra-orbital foramen being conspicuous. Its orbital or temporo-malar branch is to be shown, as are also the two short spheno-palatine branches which descend to Meckel's ganglion. A little farther forwards the posterior superior dental nerve is to be shown. This at once divides into two branches which descend upon the zygomatic surface of the superior maxilla. Sometimes these two branches arise separately from the parent trunk. Within the infra-orbital canal, in order from behind forwards, the middle and anterior superior dental branches are to be shown by carefully raising the infra-orbital nerve. The dissector should exercise his own discretion as to the removal of bone to expose the course of these two nerves.

Meckel's ganglion is now to be dissected. It is suspended from the trunk of the superior maxillary nerve in the spheno-maxillary fossa by means of the two short spheno-palatine nerves, and lies close to the spheno-palatine foramen on the inner wall of the fossa. To understand the course of the branches of this ganglion it is absolutely necessary that the dissector should have an accurate knowledge of the foramina and canals which communicate with the spheno-maxillary fossa. With this knowledge his path will be comparatively smooth, but without it he is certain to become befogged. The spheno-maxillary fossa is so much hemmed in by bone that the dissection of Meckel's ganglion and its branches is one of the nicest dissections in the body. The dissector must act with discretion and osteological knowledge, and he will no doubt clear paths with the bone-pliers which will show the course of the nerves now to be mentioned.

The spheno-palatine nerves have been already shown descending from the superior maxillary nerve to the ganglion, to which they convey sensory fibres. To understand the courses taken by the branches of the ganglion, it may be said that four paths lead from the spheno-maxillary fossa, namely (1) internal, representing the spheno-palatine foramen; (2) inferior, representing the posterior palatine canal and its two byways—the posterior and external accessory palatine canals; (3) posterior, representing (*a*) the Vidian or pterygoid canal and (*b*) the pterygo-palatine canal; and (4) antero-superior, representing the spheno-maxillary fissure. The dissector will now, it is to be hoped, be able to follow the branches of Meckel's ganglion. Taking the **internal path** through the spheno-palatine foramen, he will find (1) the superior nasal nerves, and (2) the naso-palatine nerve, or nerve of Cotunnius, all of which enter the nasal fossa. Traversing the **inferior path** and its two byways, he will find the three descending palatine nerves—great or anterior, small or posterior, and external. In following out the great or anterior descending palatine nerve through the posterior palatine canal the dissector is to show the two inferior nasal nerves which it gives off, and these can be traced without much difficulty to the nasal fossa by removing with the bone-pliers whatever of the vertical plate of the palate bone may be necessary. Pursuing the **posterior paths,** the dissector should look for (1) the Vidian nerve, which takes the Vidian or pterygoid route, and (2) the pharyngeal nerve, which passes through the pterygo-palatine canal. The orbital branch (or branches) of the ganglion takes the **antero-superior path,** and, passing through the spheno-maxillary fissure, enters the orbit.

The branches of the third part of the internal maxillary artery fall in the way of being dissected in the course of the foregoing very complicated dissection. The dissector cannot possibly hope to show everything, so that, to a certain extent, he should rest satisfied with the description given in the text. The posterior dental artery has been already dissected. The infra-orbital artery may be available for dissection. If so, it will have become evident in the course of dissecting the infra-orbital nerve, of which it is the companion in all respects. The spheno-palatine, descending palatine, Vidian, and pterygo-palatine branches may be left with this enumeration of them.

The course of the Vidian nerve, just referred to, may be exposed by removing the portion of bone which lies external to the foramen ovale, and laying open the Vidian canal. Like the preceding dissection, this is one of much nicety. The Vidian nerve, when followed backwards to the region of the foramen lacerum medium, will be found to divide into the great superficial petrosal and great deep petrosal nerves. The great superficial petrosal nerve may be followed beneath the Gasserian ganglion to the hiatus Fallopii, through which it enters the aqueduct of Fallopius to reach the geniculate ganglion of the facial nerve. The great deep petrosal nerve passes to the carotid plexus of the sympathetic.

The foramen ovale may now be laid open and the inferior maxillary nerve, with the motor root of the fifth cranial nerve, exposed. The internal pterygoid nerve is to be shown arising from the back part of the inferior maxillary immediately after the latter has received the motor root, and, in intimate

relation with that branch of the parent trunk, the otic (Arnold's) ganglion falls to receive consideration. The relation of the ganglion to the small superficial petrosal and auriculo-temporal nerves is to be borne carefully in mind. The ganglion lies immediately below the foramen ovale, between the inferior maxillary nerve and the cartilaginous part of the Eustachian tube, and the middle meningeal artery is situated behind it. The source of the motor root of the ganglion from the nerve to the internal pterygoid muscle will be readily understood, but the dissector must not overlook the small superficial petrosal nerve, which conducts to the ganglion fibres of the glosso-pharyngeal and facial nerves. The cartilaginous part of the Eustachian tube in this vicinity may be made apparent by removing, at the discretion of the dissector, the portion of the great wing of the sphenoid bone which lies internal to the foramen ovale. This dissection will allow of the branches of the otic ganglion being displayed. One branch will be found to pass upwards and backwards to the tensor tympani muscle ; a second, downwards and forwards to the tensor palati muscle ; branches to the auriculo-temporal nerve ; and a branch to the chorda tympani nerve. These, however, are extremely difficult of dissection ; nevertheless, an effort made will not be without its reward.

Deep Dissection of the Neck.—A very complicated dissection has now to be overtaken. It is impossible to lay down hard-and-fast instructions for the guidance of the dissector. He is advised to make himself master of what has been carefully stated in the text. The structures referred to are (1) the glosso-pharyngeal, (2) the pneumogastric, (3) the spinal accessory, (4) the hypoglossal, (5) the superior cervical ganglion of the sympathetic, nerves, and (6) the cervical part of the internal carotid artery, along with the upper part of the internal jugular vein. After he has done his best to study these very important structures the dissector is to revise the styloid muscles and ligaments, and thereafter the styloid process of the temporal bone is to be nipped through, and turned downwards and forwards. This procedure may be advisable in the course of the immediately preceding dissection. Without doubt the dissector will find himself in very deep water here. He should, however, try his best. When he gets clear of the difficulties in the upper part of the neck near the base of the skull, his course is fairly clear.

The spinal accessory nerve is to be completely mastered, and its bulbar part, of considerable importance, is to be shown applying itself to the ganglion of the trunk of the pneumogastric. The distribution of the spinal part of the nerve must by this time be familiar to the dissector.

The glosso-pharyngeal nerve is to be followed in accordance with the description which has been given of it in the text.

The ganglion of the trunk of the pneumogastric nerve admits of easy dissection, but must receive careful study. Its pharyngeal and superior laryngeal branches demand most careful attention, and the relation to it of the bulbar part of the spinal accessory nerve is to be specially noted. The pharyngeal branch, conducting fibres of the bulbar part of the spinal accessory, will be found to contribute largely to the pharyngeal plexus, the other contributory nerves being derived from the glosso-pharyngeal and the superior cervical ganglion of the sympathetic. The superior laryngeal nerve has already been followed out in its internal and external laryngeal branches, but the dissector should note that it must contain some of the fibres of the bulbar part of the spinal accessory nerve. The parent trunk of the pneumogastric is now to be carefully studied in its course down the neck. The dissector will be already quite familiar with it. A superior and an inferior cervical cardiac branch are to be kept in view.

As regards (1) the auricular branch of the pneumogastric, colloquially referred to as Arnold's nerve, and (2) the tympanic branch of the glosso-pharyngeal nerve (Jacobson's nerve), the dissector is recommended to accept these as described in the text, unless he desires to pursue a dissection of the most intricate nature possible.

The sympathetic cord is now to be dissected. The superior cervical ganglion, of great length and elliptical shape, can easily be shown, and an effort

should be made to show all its connections, especially its upward continuation into the carotid canal of the *pars petrosa*. The middle and inferior cervical ganglia will probably have been met with in a previous dissection, the former being associated with the inferior thyroid artery, and the latter with the vertebral artery. From each ganglion, respectively, in order from above downwards, there come the superior, middle, and inferior cervical cardiac branches; but, though these are actually present, the dissector should not feel disheartened if he cannot verify their existence.

Carotid Canal and its Contents.—The dissector is now getting into as deep water as it would be safe for him to enter. His knowledge of osteology should come to his aid. His object is to display the intrapetrous part of the internal carotid artery, and for this purpose he will remove whatever bone he deems desirable. In intimate association with this part of the internal carotid he will find the upward continuation of the cervical sympathetic cord. He may be able to show how this upward prolongation divides into two branches, external and internal, the former giving rise to the carotid plexus, and the latter going on to form the cavernous plexus. The dissector should carefully read the description given of these plexuses in the text.

The foramen lacerum posterius, or jugular foramen, is next to be dissected. Its three compartments, already familiar to the dissector, namely (1) antero-internal, transmitting the inferior petrosal sinus; (2) middle, transmitting the glosso-pharyngeal, pneumogastric, and spinal accessory nerves; and (3) postero-external, transmitting the lateral sinus, may now be completely verified by opening up the foramen referred to.

Pharynx, Soft Palate, and Mouth.—To prepare these important regions for dissection, the skull must be divided into two parts. The leading bloodvessels and nerves, as well as the trachea and œsophagus, are to be divided close to the root of the neck. The pharynx is then to be carefully separated from the prevertebral muscles quite up to the base of the skull, and the basilar region of the skull is to be divided with the chisel and mallet, aided by the saw. The front part of the skull) bearing the pharynx, along with the great bloodvessels and nerves, is to be separated from the back part, which bears the cervical portion of the vertebral column, with the prevertebral muscles. The pharynx having been distended with tow, the superior, middle, and inferior constrictor muscles are to be dissected, and whilst doing so the pharyngeal plexus of veins is to be noted. The manner in which the constrictor muscles overlap one another from below upwards is to be noted. The stylo-pharyngeus muscle and glosso-pharyngeal nerve are to be shown in the interval between the lower border of the superior constrictor and the upper border of the middle constrictor. Upon the surface of the middle constrictor muscle the dissector should make an effort to show the pharyngeal plexus of nerves, formed by the pharyngeal branches of the glosso-pharyngeal and pneumogastric, and branches from the superior cervical ganglion of the sympathetic. Between the lower part of the middle constrictor and upper part of the inferior constrictor there will be found the internal laryngeal nerve and the superior laryngeal artery. The relation of the lower border of the inferior constrictor to the œsophagus is to be noted, and passing beneath this border of the muscle there are the inferior or recurrent laryngeal nerve and artery. The pharyngeal branch of the external carotid artery and the inferior palatine and tonsillar branches of the cervical part of the facial artery may admit of being dissected at this stage, but the injection often fails to enter these arteries. Above the upper border of the superior constrictor muscle the dissector is to note the sinus of Morgagni and the pterygo-mandibular ligament, the latter separating the superior constrictor from the buccinator muscle. The wall of the pharynx, above the superior constrictor muscle, is then to be carefully opened, when the levator palati and tensor palati muscles will admit of dissection.

The dissection of the exterior of the pharynx having been completed, the interior is to be shown by opening the pharynx by means of (1) a median

vertical incision along its posterior wall, and (2) a transverse incision close to the base of the skull. The soft palate is to be studied, and the divisions of the pharynx noted, namely, the naso-pharynx, above the soft palate, and the buccal and laryngeal divisions below it. In connection with the naso-pharynx the posterior nares and the orifices of the two Eustachian tubes are to receive careful attention. The lateral pharyngeal recess, or fossa of Rosenmüller, on the lateral wall of the naso-pharynx, is to be noted, and the pharyngeal tonsil at the upper and back part, unless the median vertical incision has interfered with it. The pharyngeal bursa, below the pharyngeal tonsil, is also to be examined. The isthmus faucium, superior aperture of the larynx, and œsophagus are next to be examined.

The soft palate is now to receive careful attention. The anterior and posterior pillars of the fauces are to be carefully examined, together with the uvula. The tonsil, lying between the anterior and posterior pillars, is to receive attention, and the supratonsillar fossa may be noted. The actual dissection of the tonsil, however, is to be postponed till the muscles of the soft palate have been dissected. The levator palati and tensor palati muscles are now to be fully dissected. The relation of the levator palati to the membranous floor of the lower part of the Eustachian tube is to be carefully studied. The relation of the tensor palati to the hamular process of the internal pterygoid plate of the sphenoid bone is to be specially noted. The palato-glossus and palato-pharyngeus muscles are to be dissected, and in connection with the latter muscle the salpingo-pharyngeus is to be looked for, descending from the lower part of the cartilage of the Eustachian tube. The dissection of the muscles of the soft palate is to be completed by showing the azygos uvulæ, and the tonsil is then to be dissected.

The mouth is to be carefully examined in detail. Its two divisions, namely, the vestibule and mouth proper, will have been under observation at a previous stage of the dissection. The tongue is to receive very careful attention. At its root will be seen the epiglottis and the folds of mucous membrane in this region, namely, median and two lateral, with the glosso-epiglottidean pouch, or vallecula, on either side of the median fold, are to be noted. The fold, known as the frenum linguæ, should be carefully examined. It will be found on the under surface of the tongue a little distance from the tip. Close to each side of the frenum will be seen a small papilla, bearing the orifice of Wharton's duct, and near to this the orifice of the duct of Rivini or of Bartholin. A little posterior to this is the fold, known as the plica sublingualis, produced by the sublingual gland, and bearing the orifices of the majority of the ducts of Walther (sublingual ducts). In connection with the tongue the three sets of papillæ, namely, conical (and filiform), fungiform, and circumvallate are to be noted. The V-shaped arrangement of the latter will attract notice, and attention is to be given to the foramen cæcum. The limitation of the papillæ to the anterior two-thirds of the tongue will be evident. The extrinsic muscles of the tongue are now to be carefully revised, and their dissection completed if necessary. The intrinsic muscles of the organ fall now to be dissected, namely, the lingualis superficialis, lingualis inferior, lingualis transversus, and lingualis verticalis. The ranine artery having been already dissected, the dissector should revise with the utmost care the nerves which are distributed to the tongue.

Nasal Cavities.—To expose these cavities the skull is to be sawn through vertically on one side of the median line. The septum nasi now admits of full study. Descending upon it, in a forward direction, will be found the naso-palatine nerve, or nerve of Cotunnius, from Meckel's ganglion, and accompanying this nerve may be seen the naso-palatine branch of the spheno-palatine artery. An effort should be made to follow the palatine branch of the naso-palatine nerve through the foramen of Scarpa to the anterior part of the hard palate.

The outer wall of the nasal fossa should be studied with the closest attention. The three meatûs—superior, middle, and inferior—and the three conchæ (turbinate bones) admit of easy examination. The openings into the various meatûs are to be inspected and compared with the descriptions given

of them in the text. To expose the middle meatus completely the middle concha is to be removed with the scissors. The dissector will then see the deep curved groove, called the hiatus semilunaris, at the upper and anterior part of which will be found the infundibulum. The bulla ethmoidalis will be evident, and the atrium and vestibule are to receive attention. By clipping away the anterior part of the inferior concha a view will be obtained of the lower orifice of the nasal duct, with its imperfect mucous fold, known as the valve of Hasner. The distance of the orifice of the nasal duct from the anterior nasal aperture should be carefully inspected. A probe should be passed through the nasal duct, and the direction taken by the probe noted. A Eustachian catheter should also be passed straight backwards through the inferior meatus, and the mode of introducing it into the lower orifice of the Eustachian tube should be inspected and practised.

The dissection of the otic ganglion and of Meckel's ganglion may now be completely overtaken, it being left to the discretion of the dissector to remove whatever portions of bone may be necessary, after a perusal of the descriptions which are given of these ganglia and their branches in the text.

Larynx.—The larynx, with the tongue, is to be separated from the superior maxilla and the lateral parts of the inferior maxilla. The superior aperture of the larynx and the epiglottis are to be carefully studied, and, on looking down through the superior aperture, the rima glottidis is to be inspected, with a true vocal cord on either side of it. A little above each true vocal cord the less distinct false vocal cord may be seen. In connection with the superior aperture, the cornicula laryngis, or cartilages of Santorini, are to be noted, as well as the cuneiform cartilages, or cartilages of Wrisberg. Between the arytenoid cartilage and the back part of the ala of the thyroid cartilage the recess known as the sinus pyriformis is to be looked for, and its downward direction is to receive attention, which accounts for a foreign body being liable to become lodged within it. The position of the great cornu of the hyoid bone on either side should also receive attention, inasmuch as from an external examination of the upper part of the neck it might possibly be taken for, say, a fish-bone. In the dissection of the larynx, the dissectors, who must act in concert, should keep in view (1) the superior laryngeal nerve, its external, as well as its internal, branch; (2) the inferior or recurrent laryngeal nerve; and (3) the superior and inferior laryngeal arteries; but the latter may not be sufficiently injected for dissection. The internal laryngeal nerve will be found piercing the thyro-hyoid membrane, and the external laryngeal nerve is traceable to the crico-thyroid muscle and the lower part of the inferior constrictor muscle of the pharynx. The recurrent laryngeal nerve will be found close behind the crico-thyroid joint.

The larynx being placed with its posterior surface upwards, the two posterior crico-arytenoid muscles will admit of easy dissection by removal of the mucous membrane. They will be found upon the extensive posterior surface of the cricoid cartilage. The median vertical ridge on the posterior surface of the cricoid cartilage will be found to give origin superiorly to the longitudinal muscular fibres of the œsophagus. In dissecting the arytenoid muscle, which extends between the posterior surfaces of the arytenoid cartilages, the dissector should first show the two decussating arytæno-epiglottidei muscles. To follow out each of these muscles, the outer layer of the aryteno-epiglottidean fold of mucous membrane requires to be carefully removed. The cornicula laryngis may now be shown. They will be found to cap the arytenoid cartilages, and not far from them the cuneiform cartilages may be exposed in the back part of the aryteno-epiglottidean folds of mucous membrane, already familiar to the dissector in connection with the superior aperture of the larynx.

At this stage it may be said that the dissectors cannot possibly expect to obtain anything like a satisfactory knowledge of such an important structure as the larynx from the dissection of one specimen. The larynx should be dissected several times. However, assuming that the time and opportunities of the dissectors are limited, the cricoid and thyroid cartilages may now be studied, followed by the crico-thyroid and crico-arytenoid joints. The thyro-hyoid membrane is to be dissected, and the epiglottis is to be

examined. The crico-thyroid muscle is to be studied in so far as it can be seen without interfering with the thyroid cartilage, and its nerve-supply, namely, the external laryngeal nerve, is to be carefully noted. The part of the crico-thyroid membrane between the two crico-thyroid muscles has been already studied in connection with the operation of laryngotomy. The larynx being now placed upon its side, the greater part of the ala of the thyroid cartilage is to be removed by making (1) a vertical cut through it not far from the median line, and stopping short of the lower border, and (2) a horizontal cut extending backwards from the lower end of the vertical cut. A complete view will now be obtained of the crico-thyroid muscle, which should be removed. Thereafter the following muscles fall to be dissected, namely, the lateral crico-arytenoid, the thyro-arytenoid, and the thyro-epiglottideus. An effort should be made to show the two portions of the thyro-arytenoid muscle, namely, internal and external; and the close relation of the internal portion to the true vocal cord is to be noted. The lateral crico-arytenoid, and the whole of the thyro-arytenoid, muscles are to be very carefully removed. This will expose the lateral portion of the crico-thyroid membrane, the inferior thyro-arytenoid ligament or true vocal cord, and the wall of the ventricle of the larynx. Above the wall of the ventricle the fibres of the superior thyro-arytenoid ligament, which enter into the false vocal cord, will be found. The mucous membrane above the true vocal cord may now be removed on the side which is being dissected, when the true and false cords of the opposite side may be examined, with the ventricle of the larynx lying between them. The saccule, which is connected with the anterior part of the ventricle, is to be explored with a probe. During the course of the foregoing dissections it is presumed that the dissectors, as recommended, have been keeping in view the nerves and arteries of the larynx.

The ligaments of the larynx will have been displayed in the course of the dissection, these ligaments being the thyro-hyoid membrane, the crico-thyroid membrane, the superior thyro-arytenoid ligament, and the inferior thyro-arytenoid ligament. Two joints require close attention, namely, the crico-thyroid and the crico-arytenoid joints, and the movements allowed at these articulations are to be carefully studied. The varying conditions assumed by the rima glottidis will be found described in the text. The actions of the laryngeal muscles are to be studied with the closest attention, and the function of the epiglottis is to be considered.

Prevertebral Muscles.—The scalene muscles—anticus, medius, and posticus, if not previously dissected, should now be examined, followed by the rectus capitis anticus major, rectus capitis anticus minor, rectus capitis lateralis, and longus colli.

The vertebral artery, as it traverses the costo-transverse foramina of the upper six cervical vertebræ, is to be dissected, and the plexiform arrangement of veins around it is to be noted. The vertebral plexus of the sympathetic is also to be borne in mind.

The Ear.—The meatus auditorius externus is to be laid open with the chisel and bone-pliers, and the membrana tympani is to be carefully examined from the outside. The upper part of the membrane, called the membrana flaccida, or Shrapnell's membrane, which is attached to the notch of Rivini, is to receive special attention. The handle of the malleus will be observed extending between the mucous and fibrous layers of the membrane to a point a little below its centre, where the membrane is drawn inwards so as to give rise externally to a slight depression, known as the umbo. To expose the cavity of the tympanum, an opening is to be made through the thin lamina of bone, called the tegmen tympani, which is situated on the superior surface of the petrous portion of the temporal bone. If this opening is made external to the eminentia arcuata, it will expose the mastoid antrum. The opening is then to be enlarged with the bone-pliers, and the canal containing the tensor tympani muscle is to be laid open. The meatus auditorius internus may also be laid open. The tympanic cavity, with its intricate contents, the tensor tympani muscle, and the osseous part of the Eustachian tube, are now available for examination. The contents of the meatus auditorius internus are to be held over in the meantime. The ossicles of the tympanum, namely,

the malleus, incus, and stapes, are to be studied *in situ*. The insertions of the tensor tympani and stapedius muscles are to be made evident, and their actions studied. The stapedius muscle will be found to enter the tympanum through an opening on the summit of the pyramid on the posterior wall. The dissector need not expect to be able to show the ligaments of the tympanic ossicles, but he may make an effort to show the chorda tympani nerve. This nerve enters the tympanum through the iter chordæ posterius on the posterior wall. It then passes forwards upon the membrana tympani, lying between its mucous and fibrous layers, and it leaves the tympanic cavity by passing through the iter chordæ anterius, or canal of Huguier, at the inner end of the fissure of Glaser. The inner wall of the tympanum, with the fenestra ovalis, occupied by the foot-piece of the stapes and annular ligament, the promontory, and the fenestra rotunda, closed by the secondary membrane of the tympanum, is to receive careful attention. The dissector may note the position of the attic or epitympanic recess, which lies above the level of the upper margin of the membrana tympani, and which is divided incompletely into two compartments, outer and inner, by the head and neck of the malleus, and the body and short process of the incus. In connection with the outer compartment, he may try and familiarize himself with the pouch of Prussak, which is bounded externally by the membrana flaccida, or Shrapnell's membrane. For the pouches of Troltsch, see the description of the tympanum in the text. The osseous part of the Eustachian tube is to be carefully studied, and the mastoid cells are to be examined. For the latter purpose the mastoid process of the temporal bone is to be laid open.

The internal ear or labyrinth can only be effectually studied from specimens which have been specially prepared. By means of the chisel and bone-pliers, however, the dissector will obtain a fair amount of information regarding this exceedingly complicated region. The meatus auditorius internus having been already laid open, the roof of the labyrinth is to be removed in a fragmentary fashion. The coiled cochlea, with its two and a half turns, is to be noted, its base being directed towards the deep end of the meatus auditorius internus. Behind the cochlea will be found the vestibule, and at the back part of the vestibule the three semicircular canals are to be noted.

Contents of the Meatus Auditorius Internus.—This meatus having been already laid open, the auditory nerve, the pars intermedia of Wrisberg, the meatal portion of the facial nerve, and the internal auditory artery are to be studied. The auditory nerve will be found to break up into two divisions —vestibular and cochlear. The meatal portion of the facial nerve will be found on the upper and anterior aspect of the auditory nerve ; and the pars intermedia of Wrisberg lies between the two. The auditory and facial nerves are connected by two branches. The internal auditory artery is seldom injected.

Facial Nerve in the Aqueduct of Fallopius.—To make a complete dissection of this very intricate aqueduct, the temporal bone requires to be decalcified. An effort should, however, be made to display the aqueduct in the natural bone. The tympanic cavity having been already exposed, the position of the second portion of the aqueduct will be recognised by a ridge on the upper part of the inner wall of the tympanum above the fenestra ovalis. It is here to be laid open with the chisel and mallet. The first portion of the aqueduct, which leads from the deep end of the meatus auditorius internus, may also be laid open with the chisel and mallet in such a manner as to follow the course of the facial nerve, which is horizontally outwards between the cochlea and vestibule to the inner wall of the tympanum. The third or vertical part of the aqueduct, which descends behind the tympanum, to the stylo-mastoid foramen, can best be laid open by removing the mastoid process of the temporal bone. This process is to be sawn across in the vertical-transverse direction, posterior to the level of the stylo-mastoid foramen, into which a probe may be passed for guidance. Another cut is to be made from behind forwards, also in the vertical direction, to meet the preceding cut, close to the stylo-mastoid foramen. The included bone having been removed, the third part of the aqueduct may be reached and laid open with the chisel. In dissecting the facial nerve in the aqueduct, the following structures are to be

shown: (1) the geniculate ganglion, giving off (*a*) the great superficial petrosal nerve, (*b*) a communicating branch to the small superficial petrosal nerve, and (*c*) the external superficial petrosal nerve (inconstant), all these being situated in the first portion of the aqueduct; and (2) the following branches, arising in the third part of the aqueduct, namely, (*a*) the nerve to the stapedius muscle, (*b*) the chorda tympani nerve, and (*c*) a communicating branch to the auricular branch (Arnold's nerve) of the pneumogastric.

Articulations of the Atlas, Axis, and Occipital Bone.—The ligaments of these joints are to be dissected according to the descriptions given of them in the text, and the movements allowed between the occipital bone and the atlas, and between the atlas and axis, are to be carefully studied. In particular, the following ligaments require special attention: (1) the transverse ligament of the atlas, with the extensive synovial membrane between it and the odontoid process of the axis; (another synovial membrane is to be noted between the odontoid process and the anterior arch of the atlas); (2) the cruciform ligament, of which the preceding forms a part; (3) the lateral odontoid or alar ligaments; and (4) the posterior occipito-axial ligament, or membrana tectoria, which covers the other ligaments just enumerated.

Certain of the ligaments under consideration admit of being dissected from the exterior. These are as follows: (1) the atlanto-axial—anterior, posterior, and capsular; and (2) the atlanto-occipital—anterior, posterior, and capsular. The others, however, are situated within the spinal canal, in relation to its anterior wall. These are as follows: (1) the posterior occipito-axial, or membrana tectoria; (2) the accessory atlanto-axial ligaments; (3) the cruciform ligament, of which the transverse ligament of the atlas constitutes a part; (4) the lateral odontoid or alar ligaments; and (5) the middle odontoid, or suspensory, ligament. In order to display the ligaments which are situated within the spinal canal, the posterior arch of the atlas and the neural arch of the axis should be cut through with the saw. The tabular part of the occipital bone is to be sawn across a little behind the occipital condyles, and the posterior arch of the atlas and the neural arch of the axis are also to be sawn through. After removal of the dura mater, the first ligament to be dissected is the posterior occipito-axial, or membrana tectoria, which, as stated, covers the others, and should be detached from the axis and turned upwards after it has been examined. The cruciform ligament having been studied, the final stage in this intricate dissection consists in detaching the superior crus of the vertical part of the cruciform ligament from the basilar groove of the occipital bone, and turning it carefully downwards.

The Eyeball.—The dissection of the human eyeball can only be accomplished on perfectly fresh specimens. In order to prepare himself for this the dissector is recommended to obtain several eyeballs of the ox, say five or six. The fat, ocular muscles, conjunctiva, and capsule of Tenon are to be removed by dividing, with the scissors, the capsule of Tenon and the conjunctiva in a circular manner at the corneo-scleral junction. The adjuncts of the sclerotic can then be stripped off in a backward direction towards the optic nerve. In detaching the capsule of Tenon from the sclerotic the perisclerotic lymph-space, or Tenon's space, is to be noted. The venæ vorticosæ will probably also be seen. These are usually four in number, and they pierce the sclerotic about midway between the optic entrance and the corneo-scleral junction, at points equally distant from each other. Near the corneo-scleral junction the anterior ciliary arteries may be seen piercing the sclerotic, and around the entrance of the optic nerve the ciliary nerves and posterior ciliary arteries may be seen piercing the sclerotic.

It is well that the eyeballs should be prepared for dissection by keeping them in a 10 per cent. solution of formalin, which may sufficiently harden them. There being several ox's eyeballs at the disposal of the dissector, it will be to his advantage to make use of two of them in the following manner: (1) divide one eyeball into two halves, inner or nasal, and outer or temporal, by making an antero-posterior cut along the sagittal axis, or axis of vision—that is to say, a line connecting the anterior and posterior poles of the eyeball; and (2) divide another eyeball into two halves, anterior and posterior, by making a cut along the course of the equator. These two sections

will afford the dissector a general knowledge of the component parts of the eyeball.

Upon another ox's eyeball the sclerotic and cornea are to be examined. The sclerotic is to be carefully opened at a point in the course of the equator down to the level of the chocolate-coloured choroid. Thereafter the sclerotic is to be clipped completely round the eyeball in the course of the equator, which will divide it into two parts—anterior and posterior. These two parts are then to be carefully reflected, one forwards and the other backwards, which may be facilitated by clipping each into flaps. The dark brown tint of the inner surface of the sclerotic is to be noted, this being due to the connective-tissue layer, called the lamina fusca. Processes passing from the lamina fusca to the subjacent choroid coat will have been observed, these processes traversing the perichoroidal lymph-space.

The sclerotic having been removed in the foregoing manner, the dissector will now obtain a view of the choroid or vascular coat, easily recognised by its chocolate colour. If the dissector can succeed in washing out the pigment from the choroid, he may obtain a view of the closely-set, whorled venæ vorticosæ, which converge to four points, and form four vessels. These vessels will then present a white appearance.

Ciliary Process.—Upon another ox's eyeball a vertical-transverse section is to be made, anterior to the line of the equator. The posterior segment is to be laid aside in the meantime, for the examination of the posterior half of the retina. The vitreous body having been removed from the anterior segment, a good view will be obtained, from behind, of the ciliary processes, which radiate from the periphery of the crystalline lens.

Iris.—To obtain a view of the iris, and also of the ciliary processes, from before, the cornea is to be clipped in another eyeball around the corneo-scleral junction, and removed. This opens up the anterior part of the aqueous chamber, and the iris can now be examined. The shape of the pupil in the ox's eye is to be noted, it being much elongated in the transverse direction.

Flaps of the anterior part of the sclerotic are then to be made with the scissors, by clipping from before backwards, and thereafter they are to be turned backwards. This may enable the dissector to obtain some knowledge of the ciliary muscle, which may be recognised as a white ring in the region of the corneo-scleral junction. In front of the ciliary muscle is the canal of Schlemm. To demonstrate the canal of Petit a blow-pipe may be introduced, close to the periphery of the crystalline lens, through the posterior layer of the zonula of Zinn, behind the ciliary processes (see the text). By blowing air in, the canal of Petit may become evident, and it may then present a sacculated appearance. The suspensory ligament of the lens will be recognised as lying in front of the canal of Petit.

Crystalline Lens.—The iris having been removed, the anterior wall of the capsule of the crystalline lens is to be laid open, when the lens will escape. The outer portion of the lens will be felt to be soft, but the central portion, which constitutes the nucleus, is of firm consistence.

The posterior segment of the eyeball, recently laid aside, is now to be examined by carefully removing the vitreous body. This will enable the dissector to examine the posterior part of the retina from the front.

The foregoing dissections having been made upon the ox's eyeballs, the dissector should avail himself of the first opportunity of repeating them upon the human eyeball. For this purpose the eye of a child will suffice, or a human eye may possibly be obtained from the post-mortem room of a hospital.

The Spinal Cord.—To expose the spinal cord within the spinal canal, the vertebral and sacral grooves of the vertebral column are to be cleaned as well as possible by scraping away the muscles which occupy them. The laminæ of the vertebræ, having been thereby exposed, are to be sawn through on either side in an inwardly slanting direction, and the ligamenta subflava, which connect the laminæ, are to be divided. The chisel and mallet should also be used in this dissection. This will enable the dissector to remove the posterior wall of the spinal canal, which will be available for the dissection

of the ligamenta subflava, and the interspinous and supraspinous ligaments. The spinal canal having been laid open, the dissector will expose the epidural space, occupied by loose areolar tissue, embedded in which there is a copious plexus of veins and spinal arteries. The arteries of the spinal canal and spinal cord, though usually uninjected, are to be studied from the description given of them in the text, and, in association with the arteries, the veins are to receive attention.

Meninges of the Cord.—The dura mater, forming the theca, the arachnoid, and the pia mater, are to receive the most careful attention. The outer surface of the dura mater will be readily exposed by removing the areolar tissue and plexus of veins already referred to. The dissector will easily be able to show the tubular sheaths which the dura mater furnishes on either side to the spinal nerves as these pass through it, these sheaths being prolonged into the intervertebral foramina.

The dura matral theca is now to be carefully laid open along the middle line with a pair of scissors. This will expose the narrow interspace known as the subdural space. This space having been studied, attention is to be directed to the arachnoid membrane, beneath which is a wide interspace, called the subarachnoid space. In studying this space the dissector is to make himself familiar with its division into three compartments by means of the septum posticum, posteriorly, and the ligamenta denticulata, one on either side. The arachnoid membrane having been carefully removed, the pia mater is to be studied. Its very intimate relation to the spinal cord will be at once evident, and in connection with it the ligamenta denticulata, right and left, should receive careful attention. The manner in which the ligamenta denticulata act as suspensory ligaments to the spinal cord will be evident.

The spinal cord, along with the dura mater, is now to be removed from the spinal canal. In doing so the dissector should be careful to remove, at the same time, the lateral prolongations of the dura mater into the intervertebral foramina, containing the spinal nerves. For this purpose the intervertebral foramina may be laid open with the bone-pliers, and the actual dissection of a spinal nerve may be accomplished at this stage, if the dissector prefers it.

The external characters of the cord are then to receive the most careful attention. The glistening band, called the linea splendens, is to be noted on the anterior surface of the cord, over the course of the anterior median fissure. The cervical and lumbar enlargements are to be noted. The mode of origin of a spinal nerve by two roots is to be made evident, and the ganglion on the posterior root is to be shown. The union of the two roots immediately outside the ganglion, to form a spinal nerve, should be shown, as well as the division of the spinal nerve into anterior and posterior primary divisions. The anterior median and posterior median fissures, as well as the postero-lateral sulcus, are to receive attention. The antero-lateral and posterior columns are to be studied, as well as the columns of Goll and of Burdach. At the lower end of the cord the conus medullaris will be seen, and the arrangement of nerves, known as the cauda equina, will attract attention, in the centre of which leash the filum terminale can be shown without difficulty.

When the dissector has studied the external characters of the cord, he should endeavour to harden it by immersion in the ordinary fluid used for the preservation and hardening of the brain. This process will occupy three or four weeks, after which time transverse sections should be made through the cord at various levels. This will give the dissector some knowledge of the internal structure of the cord.

The Brain.—The brain, it is assumed, has been sufficiently hardened by immersion in the fluid used for this purpose. In their operations upon this organ it is absolutely necessary that the dissectors should treat it with the most scrupulous gentleness, supporting it on all sides where necessary, and always keeping those parts which are not under immediate dissection or observation covered with cloth saturated with the hardening fluid. With these general precautions the brain should be placed on a wooden platter,

the base being at first downwards, and a kind of nest having been made for it on the platter with pieces of cotton wadding, saturated with the hardening fluid. Two small wedge-shaped blocks should also be in constant use, each being insinuated gently underneath the lateral aspect of the corresponding cerebral hemisphere. These blocks the dissectors will find to be of great utility in keeping the parts of the brain together.

The superior surface of the brain is to receive the most careful attention, and the dissectors are recommended to study the description given of it in the text.

The brain is now to be reversed, and placed in its nest with the base upwards. In doing so it must be handled with the greatest gentleness. The dissectors have been already advised to study the base immediately after the removal of the brain from the cranial cavity. It will, however, well repay them to renew this examination in view of the importance of the parts here exposed for their careful study, *e.g.*, (1) the component parts of the encephalon; (2) the superficial origins of the cranial nerves, including the olfactory lobes; (3) the arteries, including the circle of Willis; (4) the cisternæ beneath the arachnoid, and so on (see the description given of all these in the text).

A careful effort may be made to follow out the leading arteries, but this is on no account to be pushed, as, to do so, might endanger structures of considerable importance. The branches of each vertebral artery may admit of reasonable dissection; so also may those of the internal carotid. The dissectors will find a description of the arteries in the text, and their special attention is drawn to the lenticulo-striate arteries. If the fissure of Sylvius has not been already opened up, that should now be carefully done, in order to see the gyri operti of the insula or island of Reil, lying deeply at the bifurcation of the fissure.

The bloodvessels and membranes are now to be carefully removed from the base of the brain, except in the interval between the cerebellum and medulla oblongata. For this purpose the forceps will be sufficient, aided occasionally by a pair of scissors. In doing so there is considerable risk of taking away the cranial nerves, but this must not be done. The interpeduncular region may now be studied, and the superficial origins of the cranial nerves revised, the olfactory lobe also receiving attention.

The dissectors are now advised to reverse the position of the brain, and to proceed with a systematic dissection of all its parts; but they must be prepared to encounter considerable difficulties, as it is not an easy matter to lay down hard-and-fast directions. It may be further stated that the brain should be dissected several times, and in different ways.

The brain being now placed with its base downwards, the fissures, lobes, and gyri of the cerebral hemispheres, in so far as they are visible, are to be thoroughly mastered, special attention being directed to (1) Broca's lobe; (2) the fissure of Rolando, and the gyri which bound it in front and behind; (3) the parieto-occipital fissure; and (4) the three limbs of the fissure of Sylvius. The opercula insulæ are also to be studied.

The cerebral hemispheres are then to be sliced away with a long knife until the level of the corpus callosum is reached. In doing so the dissector is to note the white matter in the centre, surrounded by the grey cortex. The corpus callosum is to be carefully inspected from above, the raphé, striæ longitudinales mesiales, and striæ longitudinales laterales being noted. The anterior cerebral arteries will also be seen sweeping backwards upon the corpus callosum. The forward and backward extent of the corpus callosum is also to be attended to.

Lateral Ventricles.—These ventricles are to be opened by means of two longitudinal cuts through the corpus callosum, each cut being made about ½ inch from the median line. Each ventricle is then to be laid completely open, so as to show the anterior and posterior cornua, by removing as much of the hemisphere as may be necessary. The various structures exposed in the floor of the lateral ventricle are to be carefully studied, namely, (1) the nucleus caudatus of the corpus striatum in the anterior cornu; (2) the tænia semicircularis, and the vein of the corpus striatum; (3) a portion of the

upper surface of the optic thalamus, resting upon which there are (*a*) the sharp lateral border of the fornix, and (*b*) the choroid plexus of the lateral ventricle; and (4) the bulb of the posterior cornu, produced by the fibres of the forceps major, and beneath this the calcar avis, or hippocampus minor, produced by the anterior calcarine fissure on the mesial surface of the cerebral hemisphere.

The middle or descending cornu of the lateral ventricle, situated within the temporal lobe, is to be laid freely open by removing a large portion of that lobe. The remarkable course of this cornu is to be noted, and the following structures, which occupy its floor, are to be studied: (1) the hippocampus major, or cornu Ammonis; (2) the fimbria, or tænia hippocampi; (3) the eminentia collateralis, or pes accessorius; and (4) the choroid plexus of the descending cornu. The swelling in which the hippocampus major terminates, called the pes hippocampi, is to be noted; and the choroidal fissure which extends from the foramen of Monro to the lower extremity of the descending cornu is to receive attention.

The corpus callosum is now to be divided transversely about its centre. On raising the anterior part the septum lucidum will be exposed, as it extends vertically between the under surface of the corpus callosum and the upper surface of the body of the fornix. The relation of the septum lucidum to the lateral ventricles having been studied, the septum is to be carefully divided with a pair of scissors, and the interval between its two layers, called the fifth ventricle, or ventricle of the septum, is to be examined. It will be evident to the dissectors that this ventricle is a closed space.

The posterior part of the corpus callosum may now be turned backwards.

The fornix falls to be studied at this stage. Thereafter it is to be divided transversely about its centre, and the two parts are to be carefully raised from the subjacent velum interpositum, and turned forwards and backwards. The two posterior pillars of the fornix will be seen to be at first connected with the under surface of the corpus callosum, but subsequently each enters the descending cornu of the lateral ventricle under the name of the fimbria, or tænia hippocampi. On the under surface of the corpus callosum, between the diverging posterior pillars of the fornix, the dissector is to note the lyra, or psalterium. On turning forwards the anterior part of the fornix, its two anterior pillars will be seen descending towards the base of the brain, and in the interval between them a partial view will be obtained of the anterior commissure. After reflection of the fornix the velum interpositum is exposed, in connection with which the two veins of Galen are to be studied, these subsequently joining to form the vena magna Galeni. The transverse fissure of the brain, by which the pia mater enters, to form the velum interpositum, may be studied at this stage, its lateral portions being the choroidal fissures.

Third Ventricle.—To expose this ventricle at the present stage the velum interpositum is to be removed with the greatest care. It is to be laid hold of with the forceps anteriorly, and turned backwards. In doing so the two choroid plexuses of the third ventricle on the under surface of the velum interpositum, as well as the ependymal roof of the third ventricle, are necessarily removed. In reflecting the back part of the velum interpositum the dissector must be careful not to disturb the pineal body, which rests upon the mesencephalon at the back part of the ventricle. This dissection will expose fully (1) the upper surface of each optic thalamus; (2) the chink-like cavity of the third ventricle, lying in the mesial line between the two optic thalami; and (3) the middle, or grey, commissure, which extends between the inner surfaces of the optic thalami. This commissure, however, being very soft, often gives way. At this period the dissectors should make themselves familiar (by revision) with the various structures which form the roof of the third ventricle. This ventricle itself is to be fully studied, and the relation of its sloping floor to the interpeduncular region at the base of the brain is to be carefully noted. The optic thalamus is to be studied, and in connection with it the following parts are to be noted: (1) the anterior tubercle; (2) the posterior tubercle, or pulvinar; (3) the corpus geniculatum externum; and (4) the stria pinealis, or medullaris, as well as the sulcus of

Monro, on its internal surface. The anterior pillars of the fornix and the anterior commissure are to be again looked to. The two foramina of Monro are to receive careful consideration, each being situated between the anterior pillar of the fornix in front and the anterior tubercle of the optic thalamus behind. It will be evident to the dissectors that the third ventricle communicates freely with the two lateral ventricles by means of the foramina of Monro. If attention is now directed to the posterior part of the third ventricle, the dissectors will see the upper opening of the aqueduct of Sylvius, by which aqueduct the third ventricle communicates with the fourth ventricle. Above the upper opening of this aqueduct, and beneath the stalk of the pineal body, the dissectors will have no difficulty in seeing the posterior commissure.

Pineal Body.—This body is situated upon the mesencephalon at the posterior part of the third ventricle, and should receive careful attention. In connection with it the following parts are to be noted : (1) the stalk, peduncle, or habenula, the dorsal portion of which forms the stria pinealis, or medullaris, already referred to in connection with the internal surface of the optic thalamus ; (2) the pineal recess, which passes backwards above the posterior commissure into the stalk, or habenula, of the pineal body (but this recess, like the optic, infundibular, and suprapineal recesses, can best be studied from plaster, or metal, casts of a mesial section through the brain) ; and (3) the trigonum habenulæ, which will come more fully into view presently.

Mesencephalon, or Mid-brain.—The mid-brain may be exposed from above by displacing backwards the anterior part of the cerebellum until the corpora quadrigemina are sufficiently exposed. This should be done with the greatest care, in order not to injure (1) the valve of Vieussens, immediately below the lower pair of quadrigeminal bodies, with the superior peduncle of the cerebellum on either side ; and (2) the slender fourth cranial nerves, which issue from the valve of Vieussens, and thereafter turn round the crura cerebri, one on either side.

The corpora quadrigemina now fall to be studied. They will easily be recognised as four rounded eminences, arranged in pairs, upper and lower, and the crucial groove which separates them from one another will attract attention. The internal geniculate body will be recognised as a small oval mass on the lateral aspect of the mesencephalon, under cover of the pulvinar of the optic thalamus. The superior and inferior brachia are to be examined, also upon the lateral aspect of the mesencephalon. A reference to the text may guide the dissectors in their examination of these brachia.

At this stage the dissectors are advised to read the description of the optic tract and its connections as given in the text. They are to make themselves familiar with the mesial and lateral roots of the optic tract, and are to note very carefully that (1) the pulvinar of the optic thalamus, (2) the external geniculate body, and (3) the upper quadrigeminal body constitute the lower visual centres, as distinguished from the higher, or cortical, visual centre in the cortex of the cuneate and lingual gyri close to the calcarine fissure on the mesial surface of the occipital lobe. The trigonum habenulæ, previously referred to, will now be fully exposed.

To complete the dissection of the mesencephalon the crura cerebri are to receive the most scrupulous attention at this stage, and it will be necessary to carefully reverse the preparation for this purpose—at all events, for revision.

The mesencephalon is now to be divided transversely between the upper and lower pairs of quadrigeminal bodies. This procedure will enable the dissectors to remove the following parts, namely, the pons Varolii, cerebellum, and medulla oblongata. On examining the cut surface the aqueduct of Sylvius will be seen in section. The division of each crus cerebri into two by the crescentic mass of grey matter, called the substantia nigra, may be evident, the upper or dorsal part being the tegmentum, and the lower or ventral part the crusta or pes. The oculo-motor sulcus on the inner surface of the crus for the third or oculo-motor nerve is to be noted, and on the outer surface will be seen the lateral sulcus. The description given of the crus cerebri in the text is to be carefully read.

Basal Ganglia of the Cerebral Hemispheres.—The pons Varolii, cerebellum, and medulla oblongata are to be laid aside in the meantime, and the dissection of what is left of the cerebral hemispheres is to be overtaken. This should be divided into two parts by a mesial, antero-posterior incision, and one of these parts is to be used for the examination of the inferior surface of the cerebral hemisphere. (The mesial surface of the cerebral hemisphere should be studied on another brain.) In this connection the orbital surface of the frontal lobe will fall to be examined, with its olfactory sulcus, triradiate sulcus, and gyri. The inferior surfaces of the temporal and occipital lobes will also admit of being examined.

The basal ganglia are then to be attended to, these being the nucleus caudatus and nucleus lenticularis of the corpus striatum, the claustrum, and the amygdaloid nucleus. Several sections through the cerebral hemispheres require to be made to obtain a knowledge of these important ganglia. On one side coronal, that is to say, vertical-transverse sections are to be made through the cerebral hemisphere from the level of the front part of the nucleus caudatus backwards to the posterior part of the optic thalamus. On the other side several horizontal sections are to be made through the structures which lie upon the floor of the lateral ventricle. In connection with these sections the dissectors are advised to read the description given of the basal ganglia, and also of the optic thalami, in the text.

Medulla Oblongata.—The dissectors are to note carefully the superficial origins of the seventh, eighth, ninth, tenth, eleventh, and twelfth cranial nerves. The anterior median fissure, with the pyramid on either side, is to be examined, and an effort is to be made to show the decussation of the pyramids. The olivary body and anterior superficial arcuate fibres are to receive attention. In connection with the posterior area of the medulla oblongata it is to be noted that it is divided into two portions, lower or closed, and upper or open. The lower portion presents in the median line the posterior median fissure, on either side of which are the following structures, in order from within outwards: (1) the funiculus gracilis, which is the continuation of Goll's column of the spinal cord, and which terminates superiorly in the clava; (2) the funiculus cuneatus, or continuation of Burdach's column of the spinal cord, terminating superiorly in the cuneate tubercle; and (3) the funiculus of Rolando, terminating superiorly in the tubercle of Rolando. The calamus scriptorius, between the two clavæ, is to be noted; but the upper or open part of the medulla had better be postponed until the floor of the fourth ventricle is under consideration. Suffice it to say that it presents on either side the restiform body. The dissectors should at this stage make themselves familiar with the cisterna magna, in connection with the subarachnoid space, this cisterna lying between the cerebellum and the medulla oblongata. Further dissection of the medulla oblongata should only be overtaken with proper assistance.

Pons Varolii.—This will admit of easy examination, except as regards its dorsal surface and internal structure. The points to be noted are as follows: (1) the basilar groove; (2) the crura cerebri, emerging from its upper part; (3) the middle peduncles, emerging from it laterally; (4) the stout sensory, and slender motor, roots of the fifth cranial nerve, also emerging from it laterally; and (5) the sixth, seventh, and eighth cranial nerves at its lower border. The dorsal surface of the pons is to be postponed for a short time, until the floor of the fourth ventricle is under examination.

Cerebellum.—Like other parts of the encephalon, the cerebellum requires to be examined from several points of view. Assuming, however, that the dissectors desire to get as much as possible out of one brain (a desire to be strongly deprecated), the component parts of the cerebellum are to be studied. On the superior surface the superior vermis and the upper surface of each hemisphere are to be examined. On the under surface the vallecula is to be noted, with the inferior vermis lying deeply in it. In connection with the inferior vermis the following parts are to be studied: (1) the tuber valvulæ; (2) the pyramid; (3) the uvula, with the furrowed band on either side of it, covered by the amygdala; and (4) the nodule, with the lateral portion of the inferior medullary velum on either side of it. On the under surface of each

cerebellar hemisphere the following parts are to be noted: (1) the postero-inferior lobule, composed of (*a*) the lobulus gracilis, and (*b*) the inferior semilunar lobule; (2) the biventral lobule; (3) the amygdala; and (4) the flocculus.

The dissectors should also make themselves familiar with the peduncles of the cerebellum, namely, the superior, middle, and inferior peduncles, right and left. The superior peduncles will be seen to converge towards the lower pair of quadrigeminal bodies, after they emerge from the cerebellar hemispheres, the valve of Vieussens having been already observed extending between them. The middle peduncles, formed by the transverse fibres of the pons Varolii, sink into each cerebellar hemisphere. The inferior peduncles, which constitute the restiform bodies, connect the cerebellar hemispheres with the upper or open part of the medulla oblongata posteriorly.

Fourth Ventricle.—This ventricle is to be laid open by making a median incision through the vermis of the cerebellum from above. This will bring into view the central collection of white matter called the corpus trapezoides. The two parts of the cerebellum are then to be gently separated, so as to expose the superior medullary velum, or valve of Vieussens, the inferior medullary velum, and the tela choroidea inferior, which lies lower down than the inferior medullary velum, and presents in the median line the foramen of Magendie. The obex is to be looked for in the lower part of the roof, where it overhangs from behind the upper opening of the central canal of the spinal cord, and on either side the ligula may be seen projecting over the epithelium of the roof for a short distance. When these structures have been divided, the floor of the fourth ventricle will be exposed. Its rhomboidal shape is to be noted. At the lower end the dissectors will observe the opening of the central canal of the spinal cord and the calamus scriptorius, and at the upper end the lower opening of the aqueduct of Sylvius. The longitudinal groove, traversing the floor between these two openings, is to be noted, and the striæ acusticæ crossing the floor towards its centre, on either side of this groove, are to receive attention. The floor is thus divided into two portions, lower and upper. The lower or medullary portion will be seen to be bounded on either side, from below upwards, by the clava, the cuneate tubercle, and the restiform body, which latter should now receive full consideration. The parts to be noted in connection with each half of the lower portion of the floor are as follows: (1) the fovea inferior, (2) the trigonum vagi, (3) the trigonum hypoglossi, and (4) the trigonum acusticum. The trigonum acusticum may be seen to be continued superiorly into a prominence called the tuberculum acusticum, over which the striæ acusticæ pass.

The upper or pontine portion of the floor will be seen to be bounded on either side by the superior peduncle of the cerebellum, and the parts to be noted in connection with each half are as follows: (1) the fovea superior; (2) the eminentia teres, produced by the subjacent fasciculus teres; (3) the locus cæruleus; and (4) an upward prolongation of the tuberculum acusticum.

The lateral recess of the fourth ventricle is to be examined. It will be found as a lateral prolongation of the ventricle, on either side, round the upper part of the restiform body. In the roof of each lateral recess is the foramen of Kay and Retzius.

The great horizontal fissure of one cerebellar hemisphere is now to be opened up, and the upper half of the hemisphere is to be removed. This will give the dissectors a view of the three cerebellar peduncles as they enter the white medullary substance in the centre of the hemisphere. This substance contains the corpus dentatum, which is a wavy lamina of grey matter enclosing white matter, and open at the upper and inner part. Through this opening many of the fibres of the superior cerebellar peduncle emerge. To expose the corpus dentatum a cerebellar hemisphere has to be cut through horizontally a little above the level of the centre. Sagittal sections are also to be made across the direction of the cerebellar laminæ, when the appearance known as the arbor vitæ cerebelli will become evident.

Lastly, with proper assistance, sections should be made through the pons Varolii, with the view of obtaining some knowledge of its internal structure.

APPENDIX.

ANATOMICAL NOMENCLATURE.

OSTEOLOGY.

(Skeletal System).

Vertebral Column.

ENGLISH.	LATIN.
Odontoid facet of **Atlas.**	Fovea dentis.
Axis.	Epistropheus.
Lateral mass of **Sacrum.**	Pars lateralis.
Auricular surface of ,,	Facies auricularis.

Thorax.

False, or asternal, **Ribs.**	Costæ spuriæ.
Ensiform process of **Sternum.**	Processus xiphoideus.
Interclavicular notch of ,,	Incisura jugularis.

Bones of the Head.

Occipital Bone.	**Os Occipitale.**
Anterior condylar foramen.	Canalis condyloideus.
Jugular process.	Tuberculum jugulare.
Superior curved line.	Linea nuchæ superior.
Inferior ,, ,,	,, ,, inferior.
Groove for lateral sinus.	Sulcus transversus.

Parietal Bone.	**Os Parietale.**
Internal surface.	Facies cerebralis.
Posterior border.	Margo occipitalis.
Anterior ,,	,, frontalis.
Superior ,,	,, sagittalis.
Inferior ,,	,, squamosus.
Parietal eminence.	Tuber parietāle.

ENGLISH.	LATIN.
Frontal Bone.	**Os Frontale.**
Frontal eminence.	Tuber frontale.
Superciliary ridge.	Arcus superciliaris.
Supra-orbital arch.	Margo supra-orbitalis.
External angular process.	Processus zygomaticus.
Temporal Bone.	**Os Temporale (Temporis).**
Fissure of Glaser.	Fissura petrotympanica.
Glenoid fossa.	Fossa mandibularis.
Articular eminence.	Tuberculum articulare.
Mastoid Portion.	*Pars Mastoidea.*
Digastric groove.	Sulcus mastoideus.
Petrous Portion.	*Pars Petrosa.*
Aqueduct of Fallopius.	Canalis facialis.
Gasserian depression.	Impressio trigemina.
Vaginal process.	Vagina processûs styloidei.
Aqueduct of the cochlea.	Canaliculus cochleæ.
Eustachian canal.	Semicanalis tubæ auditoriæ.
Sphenoid Bone.	**Os Sphenoidale.**
Pituitary fossa.	Fossa hypophysea.
Olivary eminence.	Tuberculum sellæ.
Carotid groove.	Sulcus caroticus.
Sphenoidal turbinate bones.	Conchæ sphenoidales.
Optic groove.	Sulcus chiasmătis.
External pterygoid plate.	Lamina lateralis.
Internal „ „	„ medialis.
Eustachian groove.	Sulcus tubæ auditoriæ.
Ethmoid Bone.	**Os Ethmoidale.**
Lateral mass.	Labyrinthus ethmoidalis.
Os planum, or orbital plate.	Lamina papyracea.
Superior Maxillary Bone.	**Maxilla.**
Orifice of the antrum.	Hiatus maxillaris.
Lachrymal groove.	Sulcus naso-lacrimalis.
Nasal process.	Processus frontalis.
Malar process.	„ zygomaticus.
Incisor canal.	Canalis incisivus.
Alveolar border.	Limbus alveolaris.
Malar Bone.	**Os Zygomaticum.**
Malar canal.	Canalis zygomatico-orbitalis.
Lachrymal Bone.	**Os Lacrimale.**
Hamular process.	Hamulus lacrimalis.

ENGLISH.	LATIN.
Inferior Turbinate Bone.	**Concha Inferior.**
Palate Bone.	**Os Palāti.**
Inferior turbinate crest.	Crista conchalis.
Superior ,, ,,	,, ethmoidalis.
Inferior Maxillary Bone.	**Mandibula.**
Condyle.	Processus condylaris.
Sigmoid notch.	Incisura mandibularis.
Inferior dental foramen.	Foramen mandibulare.
Hyoid Bone.	**Os Hyoideum.**
The Teeth.	
Teeth.	**Dentes.**
Ivory.	Substantia eburnea.
Enamel.	,, adamantĭna.
Nasmyth's membrane.	Cuticula dentis.
Dental arch.	Arcus dentalis.
Wisdom tooth.	Dens serōtĭnus.
Bones of the Upper Limb.	
Humerus.	**Humerus.**
Bicipital groove.	Sulcus intertubercularis.
Radius.	**Radius.**
Bicipital tuberosity.	Tuber radii.
Sigmoid cavity.	Incisura ulnaris.
Ulna.	**Ulna.**
Great sigmoid cavity.	Incisura semilunaris.
Hand.	**Manus.**
Carpus.	**Carpus.**
Scaphoid bone.	Os naviculare manûs.
Semilunar bone.	Os lunatum.
Cuneiform or pyramidal bone.	Os triquetrum.
Pisiform bone.	Os pisiforme.
Trapezium.	Os multangulum majus.
Trapezoid.	Os multangulum minus.
Os magnum.	Os capitatum.
Unciform bone.	Os hamatum.
Thumb.	Pollex.
Index finger.	Index.
Middle ,,	Digitus medius.
Ring ,,	,, minimo-proximus vel annularis.
Little ,,	Digitus minimus.

Bones of the Lower Limb.

ENGLISH.	LATIN.
Hip-bone.	**Os Coxæ.**
Articular surface of acetabulum.	Facies lunāta.
Cotyloid notch.	Incisura acetabuli.
Ilium.	*Os Ilii.*
Ilio-pectineal line.	Linea arcuata.
Ischium.	*Os Ischii.*
Os Pubis.	*Os Pubis.*
Pubic spine.	Tuberculum pubĭcum.
Pelvis.	**Pelvis.**
Brim.	Apertūra superior.
Outlet.	,, inferior.
Femur.	**Os Femoris.**
Depression for ligamentum teres.	Fovea capitis.
Outer lip of linea aspera.	Labium laterale.
Inner ,, ,, ,,	,, mediale.
Popliteal surface.	Trigōnum femoris.
Foot.	**Pes.**
Tarsus.	**Tarsus.**
Scaphoid bone.	Os naviculare pedis.
Great toe.	Hallux.
Sinus pedis.	Sinus tarsi.

ARTHROLOGY.

(Articulations or Joints).

(L. = Ligamentum).

Vertebral Column.

Intervertebral discs.	Fibro-cartilagines intervertebrales.
Circumferential fibro-laminar part of disc.	Annulus fibrosus.
Central pulp of disc.	Nucleus pulposus.
Anterior common ligament.	L. longitudinale anterius.
Posterior ,, ,,	L. ,, posterius.
Occipito-atlantal ligaments.	Membrānæ atlanto-occipitales.

ENGLISH.	LATIN.
Lateral odontoid, or alar, ligaments.	Ligamenta alaria.
Middle odontoid ligament.	L. apicis dentis.
Cruciform ligament.	L. cruciatum.

Thorax.

Anterior costo-central, or stellate, ligament.	L. capitis costæ radiatum.
Interarticular ligament.	L. capitis costæ interarticulare.
Middle costo-transverse ligament.	L. cervicis costæ.
Anterior and posterior costo-sternal ligaments.	Ligamenta sterno-costalia radiata.

Upper Limb.

Interarticular meniscus.	Discus articularis.
Suprascapular ligament.	L. transversum scapulæ superius.
Spino-glenoid ligament.	L. transversum scapulæ inferius.
Glenoid ligament of **shoulder-joint.**	Labrum glenoidale.
Internal lateral ligament of **elbow-joint.**	L. collaterale ulnare.
External lateral ligament of **elbow-joint.**	L. collaterale radiale.
Pisi-uncinate ligament.	L. piso-hamatum.
Pisi-metacarpal ligament.	L. piso-metacarpāle.

Pelvis.

Great sacro-sciatic ligament.	L. sacro-ischio-tuberans.
Small ,, ,,	L. sacro-ischio-spinosum.
Inferior or subpubic ligament.	L. arcuatum.
Interpubic disc.	Lamina fibro-cartilaginea interpubĭca.

Lower Limb.

Cotyloid ligament of **hip-joint.**	Labrum glenoidale.
Pubo-femoral ligament.	L. pubo-capsulare.
External lateral ligament of **knee-joint.**	L. collaterale fibulare.
Internal lateral ligament of **knee-joint.**	L. collaterale tibiale.
Mucous ligament (*ligamentum mucosum*).	Plica synovialis patellaris.
Alar ligaments.	Plicæ alares.

MYOLOGY.

(Muscular System).

(M. = Musculus).

Muscles of the Back.

ENGLISH.	LATIN.
Complexus.	Semispinalis capitis.

Muscles of the Upper Limb.

Serratus magnus.	M. serratus antīcus.
Biceps flexor cubiti.	M. biceps brachii.
Brachialis anticus.	M. brachialis.
Triceps extensor cubiti.	M. triceps brachii.
Long head of ,, ,,	Caput longum.
External ,, ,, ,,	,, laterale.
Internal ,, ,, ,,	,, mediale.
Pronator radii teres.	M. pronator teres.
Supinator radii longus.	M. brachio-radialis.
Supinator radii brevis.	M. supinator.

Muscles of the Lower Limb.

Quadriceps extensor cruris.	M. quadriceps femoris.
Vastus externus.	M. vastus lateralis.
Crureus.	M. ,, intermedius.
Vastus internus.	M. ,, medialis.
Subcrureus.	M. articularis genūs.
Biceps flexor cruris.	Biceps femoris.
Flexor, or musculus, accessorius.	M. quadratus plantæ.

Muscles of the Abdomen.

Poupart's ligament.	Ligamentum inguinale.
Gimbernat's ligament.	,, lacunare.
Triangle of Petit.	Trigōnum lumbale.

Muscles of the Thorax.

Triangularis sterni.	M. transversus thorācis.
Foramen quadratum of diaphragm.	Foramen venæ cavæ inferioris.

Muscles of the Head.

Epicranial aponeurosis.	Galĕa aponeurotica.
Compressor naris.	M. nasalis transversus.
Dilator alæ nasi.	M. ,, alaris.

ENGLISH.	LATIN.
Depressor alæ nasi.	M. depressor septi.
Orbicularis palpebrarum.	M. orbicularis oculi.
Tensor tarsi.	Pars lacrimalis musculi orbicularis oculi.
Depressor labii inferioris.	M. quadratus labii inferioris.
Palato-glossus.	M. glosso-palatinus.
,, pharyngeus.	M. pharyngo-palatinus.
Azygos uvulæ.	M. uvulæ.
Lingualis superficialis.	M. longitudinalis superior.
,, inferior.	M. ,, inferior.

ANGEIOLOGY.

(Vascular and Lymphatic Systems).

Heart.	Cor.
Auriculo-ventricular groove.	Sulcus coronarius.
Antero-superior surface.	Facies sterno-costalis.
Inferior surface.	,, diaphragmatica.
Vestigial fold of Marshall.	Ligamentum venæ cavæ sinistræ.
Auricle.	*Atrium.*
Interauricular septum.	Septum atriorum.
Columnæ carneæ.	Trabeculæ carneæ.
Annulus ovalis.	Limbus fossæ ovalis.
Foramina Thebesii.	Foramina venarum minimarum.
Tubercle of Lower.	Tuberculum intervenosum.
Eustachian valve.	Valvula venæ cavæ inferioris.
Thebesian valve.	,, sinûs coronarii.
Interventricular Septum.	*Septum Musculare Ventriculorum.*
Pars membranacea.	Septum membranaceum ventriculorum.
Tricuspid Valve.	*Valvula Tricuspidalis.*
Right cusp.	Cuspis medialis.
Left or infundibular cusp.	,, anterior.
Posterior or septal cusp.	,, posterior.
Mitral Valve.	*Valvula Mitralis vel Bicuspidalis.*
Semilunar or Sigmoid Valves.	*Valvulæ Semilunares.*
Corpus Arantii.	Nodulus valvulæ semilunaris.

ENGLISH.	LATIN.
Arteries.	**Arteriæ.**
(A. = Arteria vel Arteriæ).	
Pulmonary artery.	A. pulmonalis.
Arch of the Aorta.	Arcus Aortæ.
Right coronary artery.	A. coronaria dextra.
Left ,, ,,	A. ,, sinistra.
Innominate artery.	A. anonyma.
Common carotid artery.	A. carōtis communis.
External Carotid Artery.	**A. Carōtis Externa.**
Ranine artery.	A. profunda linguæ.
Facial ,,	A. maxillaris externa.
Inferior coronary artery.	A. labialis inferior.
Superior ,, ,,	A. labialis superior.
Internal Maxillary Artery.	**A. Maxillaris Interna.**
Vidian artery.	A. canalis pterygoidei.
Circle of Willis.	Circulus arteriosus.
Subclavian Artery.	**A. Subclavia.**
Internal mammary artery.	A. mammaria interna.
Superior phrenic artery.	A. pericardiăco-phrenica.
Thyroid axis.	Truncus thyreo-cervicalis.
Suprascapular artery.	A. transversa scapulæ.
Axillary Artery.	**A. Axillaris.**
Superior thoracic.	A. thoracalis suprēma.
Acromio-thoracic artery.	A. thoraco-acromialis.
Long thoracic artery.	A. thoracalis lateralis.
Dorsalis scapulæ artery.	A. circumflexa scapulæ.
Anterior circumflex artery.	A. circumflexa humeri anterior.
Posterior ,, ,,	A. ,, ,, posterior.
Brachial Artery.	**A. Brachialis.**
Superior profunda artery.	A. collateralis superior.
Inferior ,, ,,	A. ,, media.
Anastomotic artery.	A. ,, inferior.
Radial Artery.	**A. Radialis.**
Superficial volar artery.	A. volaris superficialis.
Anterior radial carpal artery.	A. radialis carpea volaris.
Radialis indicis artery.	A. radialis volaris indicis.
Ulnar Artery.	**A. Ulnaris.**
Common interosseous artery.	A. interossea communis.
Anterior ,, ,,	A. ,, volaris.
Posterior ,, ,,	A. ,, dorsalis.

ENGLISH.	LATIN.
Anterior ulnar carpal artery.	A. ulnaris carpea volaris.
Posterior ,, ,,	A. ,, ,, dorsalis.
Profunda artery.	A. volaris profunda.
Superficial palmar arch.	Arcus volaris superficialis.
Deep palmar arch.	Arcus ,, profundus.
Abdominal Aorta.	**Aorta Abdominalis.**
Capsular arteries.	A. suprarenales.
Spermatic ,,	A. spermaticæ internæ.
Cœliac axis.	A. cœliaca.
Gastric (coronary) artery.	A. gastrica sinistra.
Splenic Artery.	**A. Lienalis.**
Vasa brevia.	A. gastricæ breves.
Hepatic Artery.	**A. Hepatica.**
Pyloric artery.	A. gastrica dextra.
Superior Mesenteric Artery.	**A. Mesenterica Superior.**
Rami intestini tenuis.	A. intestinales.
Right colic artery.	A. colica dextra.
Middle ,, ,,	A. ,, media.
Inferior Mesenteric Artery.	**A. Mesenterica Inferior.**
Left colic artery.	A. colica sinistra.
Sigmoid arteries.	A. sigmoideæ.
Internal Iliac Artery.	**A. Hypogastrica.**
Gluteal artery.	A. glutæa superior.
Sciatic ,,	A. ,, inferior.
Artery of the vas deferens.	A. deferentialis.
Internal Pudic Artery.	**A. Pudenda Interna.**
Superficial perineal artery.	A. perinæi.
Artery of the bulb.	A. bulbi urethræ.
,, ,, corpus cavernosum.	A. profunda penis vel clitoridis.
External Iliac Artery.	**A. Iliaca Externa.**
Deep epigastric artery.	A. epigastrica inferior.
Cremasteric artery.	A. spermatica externa.
Femoral Artery.	**A. Femoralis.**
Anastomotic artery.	Arteria suprema genûs.

ENGLISH.	LATIN.
Popliteal Artery.	**A. Poplitea.**
Superior external articular artery.	A. superior lateralis genūs.
Superior internal articular artery.	A. ,, medialis ,,
Middle or azygos articular artery.	A. media genūs.
Inferior external articular artery.	A. inferior lateralis genūs.
Inferior internal articular artery.	A. ,, medialis ,,
Lower muscular or sural arteries.	A. surales.
Plantar Arteries.	**A. Plantares.**
Internal plantar artery.	A. plantaris medialis.
External ,, ,,	A. ,, lateralis.
Dorsal Artery of Foot.	**A. Dorsalis Pedis.**
Tarsal artery.	A. tarsĕa lateralis.
Metatarsal artery.	A. arcuata.
Veins.	**Venæ.**
	(V. = Vena vel Venæ).
Great cardiac or coronary vein.	V. magna cordis.
Small cardiac, or right conorary, vein.	V. parva ,,
Middle cardiac vein.	V. media ,,
Smallest cardiac veins.	V. minimæ ,,
Innominate veins.	V. anonymæ, dextra et sinistra.
Vena azygos major, or Right azygos vein.	V. azygos.
Vena azygos minor inferior, or Lower left azygos vein.	V. hemi-azygos.
Vena azygos minor superior, or Upper left azygos vein.	V. ,, accessoria.
Facial vein.	V. facialis anterior.
Temporo-maxillary vein.	V. ,, posterior.
Common facial vein.	V. ,, communis.
Portal vein.	V. portæ.
Splenic vein.	V. lienalis.
Internal iliac vein.	V. hypogastrica.
Internal or long saphenous vein.	V. saphĕna magna.
External or short ,, ,,	V. ,, parva.
Sinuses of the Dura Mater.	**Sinûs Duræ Matris.**
	(S. = Sinus).
Superior longitudinal sinus.	S. sagittalis superior.
Inferior ,, ,,	S. ,, inferior.
Straight sinus.	S. rectus.
Circular ,,	Sinûs intercavernosi.
Basilar ,,	Plexus basilaris.
Lateral ,,	S. transversus.
Cavernous sinus.	S. cavernosus.

ENGLISH.	LATIN.
Lymphatic System.	**Systēma Lymphaticum.**
Thoracic duct.	Ductus thoracicus.
Receptaculum chyli.	Cisterna chyli.
Right lymphatic duct.	Ductus lymphaticus dexter.

NEUROLOGY.

(The Nervous System).

Spinal Cord.	Medulla Spinalis.
Cervical enlargement.	Intumescentia cervicalis.
Lumbar ,,	,, lumbalis.
Anterior column.	Funiculus anterior.
Lateral ,,	,, lateralis.
Posterior ,,	,, posterior.
Column of Goll.	,, gracilis.
,, Burdach.	,, cuneatus.
Anterior cornu.	Columna grisea anterior.
Posterior ,,	,, ,, posterior.
Lateral ,,	,, ,, lateralis.
Central canal.	Canalis centralis.
Clarke's column.	Nucleus dorsalis.

Tracts in the Spinal Cord.

Tract of Goll.	Funiculus gracilis.
,, Burdach.	,, cuneatus.
Direct cerebellar tract.	Fasciculus dorso-lateralis cerebello-spinalis.
Tract of Gowers.	Fasciculus antero-lateralis cerebello-spinalis.
Pyramidal tract, lateral or crossed part.	Fasciculus cerebro-spinalis lateralis.
Pyramidal tract, anterior or direct part (column of Türck.)	Fasciculus cerebro-spinalis anterior.
Antero-lateral descending cerebellar tract.	Fasciculus cerebello-vestibulo-spinalis.
Anterior ground-bundle.	Fasciculus anterior proprius.
Lateral ,, ,,	,, lateralis proprius.

Encephalon.

Bulb.	Medulla Oblongata.
Pyramid.	Pyramis.
Olivary body or eminence.	Corpus olivare vel Oliva.
Restiform Body.	Corpus Restiforme.
Fillet.	Lemniscus.

ENGLISH.	LATIN.
Decussation of the Fillets.	Decussatio lemniscorum.
Superior medullary velum (Valve of Vieussens).	Velum medullāre superius vel anterius.
Inferior medullary velum.	Velum medullāre inferius vel posterius.
Red nucleus.	Nucleus ruber.
Superior quadrigeminal bodies.	Colliculi superiores.
Inferior ,, ,,	,, inferiores.
Stratum cinereum.	Stratum griseum.
Aqueduct of Sylvius.	Aquæductus cerebri.
Crusta or Pes of the Crus Cerebri.	Basis pedunculi.
Pineal body.	Corpus pineāle.
Ganglion habenulæ.	Nucleus habenulæ.
Middle or grey commissure.	Commissūra mollis.
Corpora albicantia.	Corpora mammillaria.
Bundle of Vicq d'Azyr.	Fasciculus thalamo-mammillaris.
Optic tract.	Tractus opticus.
Optic commissure.	Chiasma opticum.
Nucleus of Luys.	Corpus subthalamicum vel Nucleus hypothalamicus.
Great longitudinal fissure.	Fissura interhemispherica.
Fissure of Sylvius.	Fissura lateralis.
Fissure of Rolando.	Sulcus centralis.
Quadrate lobule of Parietal Lobe.	Præcuneus.
Island of Reil.	Insula.
Threshold of the Island of Reil.	Limen insulæ.
Convolution of the Corpus Callosum.	Gyrus fornicatus.
Limbic Lobe.	Gyrus fornicatus et gyrus hippocampi.
Uncus.	Uncus gyri hippocampi.
Hippocampus major.	Hippocampus.
Dentate Gyrus.	Fascia dentata hippocampi.
Lyra or Psalterium.	Commissura hippocampalis.
Cuneate Lobule.	Cuneus.
Radiation of the Corpus Callosum.	Radiatio corporis callosi.
Forceps minor.	Pars frontalis.
Forceps major.	,, occipitalis.
Anterior pillars of the Fornix.	Columnæ fornĭcis.
Posterior ,, ,, ,,	Crura fornĭcis.
Septum lucidum.	Septum pellucidum.
Lateral Ventricles.	**Ventriculi Laterales.**
Anterior horn.	Cornu anterius.
Middle or Lateral horn.	,, inferius.
Posterior horn.	,, posterius.

ENGLISH.	LATIN.
Third Ventricle.	Ventriculus tertius.
Fourth Ventricle.	Ventriculus quartus.
Fifth Ventricle.	Ventriculus quintus vel Cavum septi pellucidi.
Meninges.	**Meninges.**
Epidural space.	Cavum epidurale.
Subdural ,,	,, subdurale.
Subarachnoid space.	,, subarachnoidale.
Pacchionian Bodies.	Granulationes arachnoidales.

Cerebro-spinal Nerves.

(N. = Nervus vel Nervi).

Cranial Nerves.	N. Cerebrales.
First or Olfactory nerve.	N. Olfactorius.
Second or Optic nerve.	N. Opticus.
Third or Oculo-motor nerve.	N. Oculo-motorius.
Fourth or Trochlear nerve.	N. Trochlearis vel Patheticus.
Fifth or Trigeminal nerve.	N. Trigeminus.
Superior maxillary nerve.	N. Maxillaris.
Inferior ,, ,,	N. Mandibularis.
Sixth or Abducent nerve.	N. Abducens.
Seventh or Facial nerve.	N. Facialis.
Eighth or Auditory nerve.	N. Acusticus.
Ninth or Glosso-pharyngeal nerve.	N. Glosso-pharyngeus.
Jugular ganglion of ,,	Ganglion superius.
Petrous ganglion of ,,	,, petrosum.
Jacobson's nerve.	N. Tympanicus.
Tenth or Pneumogastric nerve.	N. Vagus.
Ganglion of Root of ,,	Ganglion jugulare.
Ganglion of Trunk of ,,	Ganglion nodosum.
Arnold's nerve.	N. Auricularis.
Eleventh or Spinal Accessory nerve.	N. Accessorius.
Twelfth or Hypoglossal nerve.	N. Hypoglossus.
Descendens cervicis (hypoglossi).	N. cervicalis descendens.
Cervical Plexus.	Plexus Cervicalis.
Small occipital nerve.	N. occipitalis minor.
Great auricular nerve.	N. auricularis magnus.
Superficial or Transverse cervical nerve.	N. cutaneus colli.
First cervical nerve.	N. suboccipitalis.
Great occipital nerve.	N. occipitalis major.
Third or Least occipital nerve.	N. ,, minimus.
Phrenic nerve.	N. phrenicus.

ENGLISH.	LATIN.
Brachial Plexus.	**Plexus Brachialis.**
Nerve to the Rhomboid Muscles.	N. dorsalis scapulæ.
Long thoracic nerve, or External respiratory nerve of Bell.	N. thoracalis longus.
Anterior thoracic nerves.	N. thoracales anteriores.
Median nerve.	N. mediānus.
Ulnar ,,	N. ulnaris.
Circumflex nerve.	N. axillaris.
Long subscapular nerve.	N. thoraco-dorsalis.
Twelfth thoracic ,,	N. subcostalis.
Lumbar Plexus.	**Plexus Lumbalis.**
Genito-crural nerve.	N. genito-femoralis.
Crural branch of ,,	N. lumbo-inguinalis.
Genital branch of ,,	N. spermaticus externus.
External cutaneous nerve.	N. cutaneus femoris lateralis.
Obturator nerve.	N. obturatorius.
Anterior crural nerve.	N. femoralis.
Internal or long saphenous nerve.	N. saphēnus.
Sacral Plexus.	**Plexus Sacralis.**
Small sciatic nerve.	N. cutaneus femoris posterior.
Great ,, ,,	N. ischiadicus.
External popliteal, or Peroneal, nerve.	N. peronæus communis.
Lateral cutaneous branch of peroneal nerve.	N. cutaneus suræ lateralis.
Fibular communicating nerve.	N. anastomoticus peronæus.
Tibial ,, ,,	N. communicans tibialis.
Musculo-cutaneous nerve.	N. peronæus superficialis.
Anterior tibial nerve.	N. ,, profundus.
Internal popliteal, or Tibial, nerve.	N. tibialis.
External or short saphenous nerve.	N. cutaneus suræ medialis vel N. suralis.
Internal plantar nerve.	N. plantaris medialis.
External ,, ,,	N. plantaris lateralis.
Deep division of plantar nerve.	Ramus profundus.
Pudic nerve.	N. pudendus.

SPLANCHNOLOGY.

(The Visceral System).

Digestive System.

Mouth.	Cavum oris.
Lips.	Labia oris.
Cheeks.	Buccæ.

ENGLISH.	LATIN.
Gums.	Gingivæ.
Hard palate.	Palātum durum.
Soft ,,	,, molle vel Velum pendulum palāti.
Anterior pillar of the fauces.	Arcus glosso-palatinus.
Posterior ,, ,, ,,	,, pharyngo-palatinus.
Tongue.	Lingua.
Dorsum of the tongue.	Dorsum linguæ.
Inferior surface of the tongue.	Facies inferior.
Parotid gland.	Glandula parōtica.
Parotid, or Stensen's, duct.	Ductus parōticus.
Glandula socia parotidis.	Glandula parōtica accessoria.
Wharton's duct.	Ductus submaxillaris.
Pharynx.	Pharynx.
Tonsils.	Amygdalæ, vel Tonsillæ palatīnæ.
Crypts of the tonsil.	Fossulæ tonsillares.
Pharyngeal tonsil.	Tonsilla pharyngea.
Fossa of Rosenmüller.	Recessus pharyngeus.
Orifice of the Eustachian tube.	Ostium pharyngeum tubæ auditoriæ.
Eustachian cushion.	Torus tubæ auditoriæ.
Gullet (Œsophagus).	Gula.
Stomach.	**Ventriculus.**
Fundus (Cardiac end).	Fundus ventriculi.
Œsophageal orifice.	Cardia.
Pyloric orifice	Pylorus.
Plicæ villosæ.	Plicæ gastricæ.
Small Intestine.	**Intestinum Tenue.**
Valvulæ conniventes.	Plicæ circulares.
Glands of Brunner.	Glandulæ duodenales.
Crypts of Lieberkühn.	Glandulæ intestinales.
Solitary glands.	Noduli lymphatici solitarii.
Agminated glands, or Peyer's patches.	,, ,, aggregati.
Large Intestine.	**Intestinum Crassum.**
Ileo-colic, or ileo-cæcal, valve.	Valvula coli.
Upper segment of ,, ,,	Labium superius.
Lower segment of ,, ,,	,, inferius.
Retinacula of ,, ,,	Frenula valvulæ coli.
Vermiform appendix.	Processus vermiformis.
Ascending colon.	Colon vel Colum dextrum.
Hepatic flexure.	Flexūra dextra coli.
Transverse colon.	Colon transversum vel medium.

ENGLISH.	LATIN.
Splenic flexure.	Flexūra sinistra coli.
Descending colon.	Colon sinistrum.
Iliac colon.	Colon iliăcum.
Pelvic colon	Colon pelvĭcum.
Sacculi of colon.	Haustra coli.
Crescentic folds between the sacculi.	Plicæ semilunares coli.
Rectum.	Intestinum rectum.
Rectal valves, or Valves of Houston.	Plicæ transversales recti.
Anal canal.	Pars analis intestini recti.
Columns of Morgagni.	Columnæ canalis analis.
Liver.	**Hepar.**
Suprarenal impression.	Impressio suprarenalis.
Gastric ,,	,, gastrica.
Colic ,,	,, colica.
Renal ,,	,, renalis.
Duodenal ,,	,, duodenalis.
Omental tuberosity.	Tuber omentale.
Quadrate lobe.	Lobus quadratus.
Caudate lobe.	Lobus vel Processus caudatus.
Fossa of the inferior vena cava.	Fossa venæ cavæ inferioris.
,, (fissure) of the ductus venosus.	,, ductūs venosi.
Umbilical fissure.	,, venæ umbilicalis.
Portal, or Transverse, fissure.	Porta hepătis.
Fossa of the gall-bladder.	Fossa vesĭcæ felleæ.
Round ligament.	Ligamentum teres hepătis vel Ligamentum venosum.
Hepatic duct.	Ductus hepaticus.
Capsule of Glisson.	Capsula fibrosa.
Gall-bladder.	**Vesica Felleа.**
Cystic duct.	Ductus cysticus.
Common bile-duct.	,, communis cholēdochus.
Spleen.	**Lien.**
Diaphragmatic surface.	Facies diaphragmatica.
Gastric surface.	,, gastrica.
Renal ,,	,, renalis.
Basal ,,	,, basalis.
Kidneys.	**Rēnes** (singular, **Rēn**).
Muscular surface.	Facies muscularis.
Visceral ,,	,, visceralis.
Pyramids of Malpighi.	Pyramides renales.
Columnæ Bertini.	Columnæ renales.

ENGLISH.	LATIN.
Medullary rays.	Pars radiata.
Labyrinth.	,, convolūta.
Malpighian corpuscles.	Corpuscula renis.
Uriniferous tubules.	Tubuli renales.
Renal arteries.	Arteriæ renis.
Renal veins.	Venæ renis.
Urinary Bladder.	**Vesica Urinaria.**
Base of bladder.	Fundus vesicæ.
Summit, or Apex, of bladder.	Vertex vesicæ.
Body of bladder.	Corpus vesicæ.
Urethral orifice of bladder.	Orificium internum urethræ.
Fibrous cord of the urachus.	Ligamentum umbilicale medium.
Peritoneal coat.	Tunica serosa.
External muscular coat.	Stratum musculare externum.
Middle ,, ,,	,, ,, medium.
Internal ,, ,,	,, ,, internum.
Sphincter muscle.	Annulus urethralis.
Submucous coat.	Tela submucosa.
Mucous coat.	Tunica mucosa.
Male Reproductive Organs. Testicles.	**Orgăna Genitalia Virilia. Testes.**
Tunica vaginalis testis.	Lamina visceralis.
Tunica ,, scroti.	,, parietalis.
Globus major of Epididymis.	Caput epididymis.
Globus minor ,,	Cauda ,,
Organ of Giraldès.	Paradidymis.
Digital fossa.	Sinus epididymis.
Coni vasculosi.	Lobuli epididymis.
Vas deferens.	Ductus testis.
Spermatic cord.	Funiculus spermaticus.
Penis.	**Penis.**
Upper surface of penis.	Dorsum penis.
Under ,, ,,	Facies urethralis.
Body of penis.	Corpus penis.
Prepuce.	Præputium.
Glands of Tyson.	Glandulæ præputiales.
Corpora cavernosa.	Corpora cavernosa penis.
Corpus spongiosum.	Corpus cavernosum urethræ.
Prostate Gland.	**Glandula Prostatica vel Prostadica.**
Base of prostate gland.	Basis prostadis.
Apex of ,, ,,	Apex prostadis.

ENGLISH.	LATIN.
Male Urethra.	**Urethra Virilis.**
Prostatic part.	Pars prostatĭca vel prostadĭca.
Membranous part.	,, membranacea.
Spongy part.	,, cavernosa.
Meatus urinarius.	Orificium externum urethræ.
Glands of Cowper.	Glandulæ bulbo-urethrales.
Glands of Littré.	,, urethrales.
Female Reproductive Organs.	**Orgăna Genitalia Muliebria vel Femĭnĕa.**
Ovary.	Ovarium.
Upper, or Tubal, pole of ovary.	Extremitas tubalis.
Lower, or Uterine, pole of ovary.	,, uterina.
Anterior border of ovary.	Margo mesovarii.
Peritoneal fold of ovary.	Mesovarium.
Ligament of ovary.	Ligamentum proprium ovarii.
Peritoneal fossa of ovary.	Fossa ovarii.
Graafian follicles.	Folliculi vesiculosi oöpherii.
Discus proligerus.	Cumŭlus oöpherii.
Fallopian Tube.	**Tuba Uterina.**
Duct of Gartner.	Ductus epoöpherii longitudinalis.
Hydatids of Morgagni.	Appendices vesiculosi.
Uterus.	**Uterus.**
Anterior surface.	Facies vesicalis.
Posterior ,,	,, intestinalis.
Cavity of the cervix.	Canalis cervicis uteri.
Plicæ palmatæ.	Arbor vitæ uterina.
Broad ligament.	Ligamentum latum uteri.
Round ,,	,, teres ,,
Peritoneal coat.	Tunica serosa.
Vagina.	**Vagina.**
Lower part of anterior column.	Carina urethralis.
Vulva, or Pudendum.	**Pudendum muliebre vel femineum.**
Fourchette.	Frenulum labiorum pudendi.
Female urethra.	Urethra muliebris vel femĭnĕa.
Meatus urinarius.	Orificium externum urethræ.
Mammary Gland.	**Mamma.**
Glands of Montgomery.	Glandulæ areolāres.
Galactophorous ducts.	Ductŭs lactiferi.
Ampulla of galactophorous duct.	Sinus lactiferus.

ENGLISH.	LATIN.
Larynx.	**Larynx.**
Thyroid cartilage.	Cartilago thyroidea.
Oblique line.	Linea obliqua.
Cricoid cartilage.	Cartilago cricoidea.
Arytenoid cartilages.	Cartilagines arytænoideæ.
Cartilages of Santorini.	,, corniculatæ.
Cartilages of Wrisberg.	,, cuneatæ.
Epiglottis.	Epiglottis.
Tubercle, or Cushion, of epiglottis.	Pulvinar epiglottideum.
Superior aperture of the larynx.	Aditus laryngis.
Cavity of the larynx.	Cavum laryngis.
Superior thyro-arytenoid ligament.	Ligamentum ventriculosum.
Inferior thyro-arytenoid ligament.	,, vocale.
False vocal cords.	Plicæ ventriculosæ.
True ,, ,,	,, vocales.
False glottis.	Glottis spuria.
True ,,	Glottis vera, vel Rima glottidis.
Vocal glottis.	Pars intermembranacea.
Respiratory glottis.	,, intercartilaginea.
Ventricle of the larynx.	Ventriculus laryngis.
Saccule ,, ,,	Appendix ventriculi.

Organs of Sense.

Eye.	**Oculus vel Orgănum visûs.**
Eyeball.	Globus oculi.
Capsule of Tenon.	Fascia bulbi.
Sclerotic coat.	Sclera.
Canal of Schlemm.	Sinus venosus scleræ.
Membrane of Bowman.	Lamina elastica anterior.
Membrane of Descemet, or of Demours.	,, ,, posterior.
Choroid coat.	Tunica chorioidea.
Membrane of Bruch.	Lamina basalis.
Ciliary body.	Corpus ciliare.
Zonula of Zinn.	Zonula ciliaris.
Valve of Hasner.	Plica lacrimalis.
Ear.	**Auris Orgănum Auditûs.**
External Ear (Auricle).	**Auris Externa (Auricula).**
Upper portion of concha, above crus helicis.	Cymba conchæ.
Lower portion of concha, below crus helicis.	Cavum conchæ.
Tubercle of Darwin.	Tuberculum auriculæ.

ENGLISH.	LATIN.
Fossa of the helix.	Scapha.
Fossa of the antihelix.	Fossa triangularis.
Eminence on cranial aspect of concha.	Eminentia conchæ.
Hairs of tragus and antitragus.	Barba hircina.
External auditory meatus.	Meatus acusticus externus.
Sweat-glands of auditory meatus.	Glandulæ ceruminosæ.
Middle Ear.	**Auris Media.**
Tympanic cavity.	Cavum tympani.
Outer wall of ,,	Paries membranacea.
Inner ,, ,,	,, labyrinthica.
Anterior wall ,,	,, carotica.
Posterior ,, ,,	,, mastoidea.
Roof ,, ,,	,, tegmentalis.
Floor ,, ,,	,, jugularis.
Tympanic Membrane.	**Membrāna Tympani.**
Shrapnell's membrane.	Membrāna vel Pars flaccida.
External layer of tympanic membrane.	Stratum cutaneum.
Middle layer of tympanic membrane.	Membrāna propria (Stratum radiatum et stratum circulare).
Internal layer of tympanic membrane.	Stratum mucosum.
Fenestra ovalis.	Fenestra vestibuli.
Fenestra rotunda.	,, cochleæ.
Secondary membrane of the tympanum.	Membrāna tympani secundaria.
Mastoid antrum.	Antrum mastoideum vel tympanicum.
Eustachian tube.	Tuba auditoria.
Tympanic orifice of tube.	Ostium tympanicum.
Pharyngeal ,, ,,	,, pharyngeum.
Tympanic Ossicles.	**Ossicula Auditûs.**
Malleus.	**Malleus.**
Handle.	Manubrium.
Long process.	Processus longus.
Short ,,	,, brevis.
Incus.	**Incus.**
Long process.	Crus longum.
Short ,,	,, breve.

ENGLISH.	LATIN.
Stapes.	**Stapes.**
Anterior crus.	Crus anterius.
Posterior ,,	,, posterius.
Foot-plate.	Basis.
Internal Ear.	**Auris Interna.**
Osseous Labyrinth.	**Labyrinthus Osseus.**
Vestibule.	**Vestibulum.**
Fovea spherica.	Recessus sphericus.
,, elliptica.	,, ellipticus.
Cochlea.	**Cochlea.**
Base of cochlea.	Basis.
Apex ,,	Cupola.
Modiolus.	Columella.
Spiral canal of the modiolus.	Canalis spiralis modioli.
Internal auditory meatus.	Meatus acusticus internus.
Membranous Labyrinth.	**Labyrinthus Membranaceus.**
Canal of Hensen.	Ductus reuniens.
Membranous cochlea.	,, cochlearis vel Scala media.
Membrane of Reissner.	Membrana vestibularis.
Basilar membrane.	,, basilaris.
Nose.	**Nasus.**
Cartilage of the septum.	Cartilago septi nasi.
Vomerine cartilage.	Cartilago vomero-nasalis Jacobsoni.
Upper lateral nasal cartilage.	Cartilago nasi lateralis superior.
Lower lateral nasal cartilage.	,, ,, ,, inferior vel Cartilago apertūræ nasi.
Outer plate of nasal cartilage.	Crus laterale.
Inner plate of ,, ,,	Crus mediale.
Superior meatus.	Meatus nasi superior.
Middle ,,	,, ,, medius.
Inferior ,,	,, ,, inferior.
Glands of Bowman.	Glandulæ olfactoriæ.

GLOSSARY

Abdōmen, probably from *abdo*, I hide or conceal; perhaps a corruption of **adipōmen,** from *adeps*, the soft fat of animals.
Aberrant, wandering from the normal source.
Acervŭlus, a little heap.
Acetabulum, a vessel for holding vinegar; a juggler's cup.
Acinus, any juicy berry with stones, *e.g.*, the grape; the kernel in the berry.
Acrocephalus, pointed or conical head.
Acromion, the point or summit of the shoulder.
Acusticus, -a, -um, pertaining to sound, or to the sense of hearing.
Adamantoblast, enamel-germ.
Aditus, an approach or access.
Adnāta, born to.
Adrenal, near to, or pertaining to, the kidney.
Advehens, carrying to.
Afferent, carrying to.
Agger, a mound or rampart.
Agminated, in groups.
Ala, a wing.
Albicans, white.
Albuginea, whitish.
Allantois, sausage-like.
Alveolus, a little trough.
Alveus, a trough.
Amacrine, without a long fibre.
Ambiguus, dark, obscure.
Ammōnis, cornu, horn of Ammon, who was represented as having the head of a ram.
Amphiarthrosis, literally, articulation on both sides.
Ampulla, a flask.
Amygdala, an almond.
Anastomosis, literally, an outlet; the communication of branches of vessels with one another.
Anconēus, pertaining to the elbow.
Ankylosis, bony union between two bones which are normally separate.
Annulus, a little ring.
Ansa, a handle, haft, or brace.
Anserinus, pertaining to a goose.
Antecubital (Anticubital), before the elbow.
Anticus, in front, anterior.
Antinion, facing the inion.
Antrum, a cave or cavity.
Anus, a ring.
Aorta, literally, the lower end of the trachea; a carrier.
Aponeurosis, an expansion from a tendon.
Apophysis ('grow from'), a process or swelling on a bone.
Arachnoid, like a spider's web.
Arcuatus, curved.
Areola, a small open place.
Artery, literally, the trachea; a bloodvessel which carries the blood from the heart.

Arthrodia, from a Greek word meaning 'a joint'; gliding is implied.
Arytenoid, pitcher-like.
Aspera, rough.
Asterion, a star.
Astragalus, the ankle-bone; a die (pl. dice).
Atlas, a support.
Atresia, imperforation.
Atrium, the hall in a Roman house.
Attollens, raising up, elevating.
Attrahens, drawing to or towards.
Auditory, pertaining to the organ, or sense, of hearing.
Auricle, the external ear.
Azygos, without a yoke, single.

Bacillary, pertaining to a small staff or rod.
Balănus, an acorn.
Barba, a beard.
Basilar, belonging to the base.
Basilic, royal, important.
Basion, base.
Biceps, having two heads.
Bicornis, two-horned.
Biventer, having two bellies.
Brachium, the arm.
Brachycephalic, short-headed.
Bregma, from a Greek verb meaning 'to moisten.'
Bronchial, pertaining to the windpipe.
Bronchiole, a little bronchus.
Bronchus, literally, a draught; the windpipe.
Bubonocele, a tumour in the groin.
Buccinator, a trumpeter.
Bulla, a knob.
Bursa, a sac containing fluid.

Cacūmen, tip, peak, or end.
Cæcum, blind.
Cæruleus, dark blue.
Calamus, a reed-pen.
Calcaneum, the heel.
Calcar, a spur.
Calcination, reduction to a powder (or lime) by heat.
Calcis, of the heel.
Calix, a cup or goblet.
Callosum, hard, thick.
Calvaria (*calva*, the bald scalp), the upper part of the skull.
Cancellated, lattice-formed, reticulated.
Caninus, canine.
Canthus, the corner of the eye.
Capillary, pertaining to the hair; a vessel of hair-like minuteness.
Capitellum, a small head.
Cardia, the opening of the stomach; the heart.
Cardiac, pertaining to the heart.
Cardinal, principal or chief.
Carina, a keel.
Carneæ, pertaining to flesh.
Carōtid, stupefying; or perhaps from two Greek words meaning 'head' and 'ear.'
Carpus, the wrist.
Caruncula, a little piece of flesh.
Cauda, a tail.
Caudal, pertaining to a tail.
Caudate, pertaining to a tail.
Cavernous, full of hollows or cavities.
Centimetre (cm.), $\frac{2}{5}$ of an English inch.
Cephalic, pertaining to the head.
Cerăto, horny.
Ceruminous, pertaining to wax.
Chiasma, two lines placed like an **X**.
Choāna, a funnel.
Choledŏchus, bile-receiving.
Chondral, pertaining to cartilage.
Choroid (Chorioid), like skin.
Cinereus, ash-coloured.
Cingulum, a small girdle.
Circumflexus, bent around.
Cisterna, a cistern or reservoir.

Claustrum, a bolt, barrier, or inclosure.
Clava, a club.
Clavicle, from *clavis*, a key.
Cleido-, pertaining to the clavicle.
Clinoid, like a bed (bed-post).
Clitoris, from a Greek verb meaning 'I shut up' or 'enclose.'
Clivus, a slope.
Cloāca, a sewer or drain.
Coccyx, a cuckoo.
Cochlea, a snail.
Cochleariformis, spoon-like.
Cœliac, pertaining to the belly.
Collicŭlus, a little hill.
Colon, the great gut.
Comes, a companion.
Complexus, literally, folded together; encompassing.
Conarium, a small cone.
Concatenatæ, chained together.
Concha, a shell.
Condyle ('knuckle'), a small round prominence covered by cartilage.
Conjunctiva, connecting.
Conniventes, winking or blinking.
Conoid, cone-like.
Convolūta, rolled together.
Coracoid, like a crow or raven.
Cordiform, heart-shaped.
Cornea, horny.
Corniculum, a little horn.
Corōnal, literally, pertaining to a crown; transverse.
Coronary, encircling.
Coronoid, like a crooked beak.
Corrugator, a wrinkler.
Cortex, the bark or outer covering.
Costal, pertaining to a rib.
Cotyloid, cup-like.
Coxa, the hip.
Cranium, the skull.
Crassum, thick, dense, or bulky.
Cremaster, a suspender.
Cretin, a simple-minded person.
Cribriform, sieve-like.
Cribrosa, perforated with sieve-like pores.
Cricoid, like a ring.
Crucial, pertaining to, or shaped like, a cross.
Crural, pertaining to the leg.
Cryptorchismus, concealment of the testis.
Cryptozygous, hidden arches.
Cubitum, the elbow.
Cuculiaris, pertaining to a cowl or hood.
Culmen, the top or summit.
Cuneate, wedge-shaped.
Cuneus, a wedge.
Cupola, a dome.
Cymba, a boat or skiff.
Cystic, pertaining to the gall-bladder.
Cytoplasm, formative yolk.

Dacryon, a tear.
Dartos, skinned or flayed.
Deciduous, falling away.
Deferens, carrying away.
Detrūsor, from *detrūdo*, I drive away.
Deutoplasm, nutritive yolk.
Dia-, through or between.
Diaphragm, a partition.
Diaphysis ('grow between'), the shaft of a bone, or the part which grows between the epiphyses.
Diarthrosis, an 'apart' joint (without intervening substance).
Dieneephalon, the 'tween-brain or inter-brain.
Digastric, having two bellies.
Diploë, a doubling.
Diverticulum, from *diverto*, 'I separate,' or 'part,' or 'go a different way.'
Dolichocephalic, long-headed.
Dorsal, pertaining to the back aspect.
Dorsum, the back.
Duodēnum, twelve.

Ebur, -ŏris, ivory.
Eburnea, pertaining to ivory.
Ectopia, a displacement.
Efferent, carrying out.
Emboliformis, beak-shaped or wedge-shaped.
Emissary, sent out.
Emulgent, milking, straining out.
Encephalon, the contents of the head or skull.
Endocardium, 'within the heart'; the lining membrane of the cardiac chambers.
Endognathion, literally, inner jaw.
Endosteum, 'within a bone'; the medullary membrane.
Ensiform, sword-like.
Entomion, a notch.
Ependyma, from a Greek word meaning 'clothing.'
Ephippium, a saddle.
Epi-, upon or over.
Epicardium, upon the heart.
Epididymis, upon the testicle.
Epiotic, upon or over the ear.
Epiphysis ('grow upon'); a process of a bone which has a secondary centre of ossification.
Epiploön, from a Greek verb meaning 'I sail upon.'
Epipteric, upon a wing.
Epoöphoron, upon the egg-bearing organ.
Equina, pertaining to a horse.
Erythrŏblast, red germ.
Ethmoid, sieve-like.
Exognathion, literally, outer jaw.
Exomphalos, out of the navel.

Facet (French, *facette*, a little face), a small plane articular surface.
Falciform, sickle-like.
Falx, a sickle.
Fascia, a band.
Fasciculus, a small bundle.
Fauces, the throat.
Fel, fellis, the gall-bladder.
Fellea, pertaining to the gall-bladder.
Femur, the thigh.
Fenestra, an opening, a window.
Ferruginea, pertaining to iron-rust.
Fibula, a buckle, clasp, or brace
Filum, a thread.
Fimbria, a fringe.
Fimbriātum, fringed.
Fissure, a cleft or slit.
Fistula, a pipe or tube.
Flocculus, a little lock of wool.
Follicle, a small bag or sac.
Fontanelle, a small spring.
Foramen, an aperture or a hole.
Forceps, a claw of a beetle.
Fornicatus, pertaining to an arch.
Fornix, an arch or a vault.
Fossa, a ditch or trench.
Fourchette, a fork.
Fovea, a small pit.
Foveola, a small pit.
Frenum, a bridle.
Frenulum, a small bridle.
Frontal, pertaining to the forehead.
Fundiform, sling-like.
Funicular, pertaining to a cord.
Funiculus, a slender rope, a cord.
Furcalis, pertaining to a two-pronged fork.
Furcula, a small two-pronged fork.
Fusca, dark or dusky.

Galactophorous, milk-carrying.
Galĕa, a helmet.
Gallinaginis, of a woodcock.
Gallus, a cock.
Ganglion, a swelling or excrescence.
Gastric, pertaining to the stomach.
Gastrocnemius, the belly of the leg.
Gemellus, paired or double.
Geminus, double or twofold
Geniculate, knee-like.
Genio-, pertaining to the chin.
Genu, the knee.

Ginglymus, a hinge.
Glabella, without hair ; smooth.
Gladiolus, a small sword.
Glenoid, like a shallow socket.
Globosus, round or spherical.
Globus, a globe or sphere.
Glomerulus, a small ball of thread.
Glosso-, pertaining to the tongue.
Glottis, the mouthpiece of a flute.
Gluteal, pertaining to the buttock.
Gnathic, pertaining to the jaw.
Gnathion, the jaw.
Gomphosis, a bolting together.
Gonion, an angle.
Gracilis, slender.
Grisea, grey.
Gubernaculum, a rudder.
Gula, the gullet.
Gustatory, pertaining to taste.
Guttural, pertaining to the throat.
Gyrus, a circle ; a crook.

Habenula, a small rein.
Hallux, the great toe.
Ham, see p. 415 (footnote).
Hamular, hook-shaped.
Harmonia, a fitting together.
Haustrum, a machine for drawing water.
Helicine, spiral.
Helicotrēma, hole of a spiral.
Helix, a coil or spiral.
Hemorrhoidal, pertaining to hemorrhoids or piles.
Hepar, the liver.
Hepatic, pertaining to the liver.
Hernia, a sprout ; a rupture.
Hiatus, a gap.
Hilum, a little thing, a trifle.
Hippocampus, a seahorse.
Hircina, pertaining to a goat.
Homodynamic, having the same force or value.
Homogenesis, one and the same generation.
Homologous, agreeing in position or structure.
Humerus, the upper part of the arm ; the shoulder.
Hyaline, glassy.
Hyaloid, like glass.
Hydatid, a watery vesicle.
Hydrocele, a watery tumour.
Hymen, a thin skin or membrane.
Hyoid, like the Greek letter upsilon.
Hypo-, beneath or under.
Hypophysis, ' grow beneath.'
Hypothenar, beneath the palm of the hand.

Ileum, implying twists or coils.
Ilium, the flank.
Ima, lowest.
Impar, dissimilar (in number), unequal.
Incisivus, cutting into.
Infundibulum, a funnel.
Infundibuliform, funnel-shaped.
Inguinal, pertaining to the groin.
Inion, literally, the occiput.
Innominatum, unnamed.
Insula, an island.
Intercalary, inserted.
Internodium, between two joints.
Interpositum, placed between.
Interstitial, belonging to interstices or small intervals separating the minute parts of bodies.
Iris, the rainbow.
Ischiatic, pertaining to the hip.
Ischium, the hip.
Iter, a passage or road.

Jejunum, empty.
Jugal, yolking.
Jugular, pertaining to the throat.
Jugum, a yolk.

Labrum, a basin.
Lachrymal, pertaining to tears.
Laciniosum, full of folds, indented, jagged.
Lacteal, pertaining to milk.
Lactiferous, milk-carrying.

Lacuna, a hollow or cavity.
Lacunar, pertaining to a hollow or gap.
Lamella, a small plate.
Lamina, a plate.
Lateral, external.
Latissimus, broadest.
Latum, broad.
Lemniscus, a ribbon.
Leptorhine, having small narrow nostrils.
Levator, a lifter or raiser.
Lien, the spleen.
Liēno-, pertaining to the spleen.
Ligament, a band.
Ligula, a little tongue.
Limbous, pertaining to a border.
Limbus, a border.
Limen, a threshold.
Linea, a line.
Lingual, pertaining to the tongue.
Lingula, a little tongue.
Longissimus, longest.
Lumbar, pertaining to the loin.
Lumbricalis, pertaining to an earth-worm.
Lunar, pertaining to the moon.
Lunula, a little moon.
Luteum, muddy, like clay.
Lymphatic, from *lympha*, pure or spring water; lymph.
Lyra, a lyre.

Macula, a spot.
Malar, pertaining to the cheek.
Malleolus, a small hammer or mallet.
Malleus, a hammer or mallet.
Mamma, a breast or pap.
Mammilla, a little breast or pap.
Mandible, the chewing bone.
Manubrium, a handle or hilt.
Massēter, the chewing muscle.
Mastoid, breast- or pap-like (nipple-like).
Maxilla, jaw.
Meatus (pl. **meatūs**), a passage or canal.
Mediastinum, standing in the middle.
Medulla, marrow.
Megacephalic, having a large head.
Megaseme, great index.
Meninges, membranes.
Meniscus, a crescent.
Mental, pertaining to the chin.
Meso-, middle.
Mesaticephalic, pertaining to an intermediate head.
Mesencephalon, the mid-brain.
Mesentery, middle intestine.
Mesial, internal.
Mesocephalic, pertaining to an intermediate head.
Mesogastrium, middle belly.
Mesognathion, middle jaw.
Meso-nephros, mid-kidney.
Mesorhine, pertaining to an intermediate nose.
Mesosalpinx, middle of trumpet or tube.
Mesoseme, intermediate index.
Meta-, after or beyond.
Meta-nephros, hind-kidney.
Metencephalon, the after-brain.
Metopic, pertaining to the forehead.
Metopism, persistence of the metopic or frontal suture.
Microcephalic, pertaining to a small head.
Microseme, small index.
Millimetre (**mm.**), slightly less than $\frac{1}{25}$ of an English inch.
Minimæ, least, smallest.
Mitral, resembling an Asiatic head-dress.
Modiolus, the nave of a wheel.
Molar, pertaining to a mill, or to grinding.
Montānum, pertaining to a mountain.
Monticulus, a small mountain.
Morbus, a disease.
Muliebris, pertaining to a woman, feminine.

Multifidus, many cleft ; divided into many parts.
Myelencephalon, marrow-brain.
Myeloplaxes, marrow-plates.
Myentericus, pertaining to the muscular tissue of the bowel.
Mylo-, pertaining to a mill.
Myocardium, the muscular tissue of the heart.
Myoides, muscle-like.
Myrtiform, like a myrtle-berry.

Naris (pl. **nares**), a nostril.
Nasal, pertaining to the nose.
Natal, pertaining to the buttock.
Natis (pl. **nates**), the buttock.
Navicular, pertaining to a boat.
Nephros, a kidney.
Neural, pertaining to a nerve.
Neuroglia, ' nerve and glue.'
Nictitans, winking.
Norma, a rule or measure, (aspect).
Notochord, string or cord of the back.
Nucha, the nape of the neck.
Nucleus, a kernel.
Nymphæ, demi-goddesses, or inferior deities, of the fountains.

Obelion, a horizontal line (perhaps a little spit).
Obex, a bolt.
Obturator, a stopper-up.
Occipital, against the head.
Odontoblast, a tooth-germ.
Odontoid, tooth-like.
Odoriferæ, carrying odours.
Œsophagus, food-carrier.
Olecranon, head of the elbow.
Olfactory, pertaining to smell.
Olivary, pertaining to an olive.
Omentum, a caul or net ; the fat-skin.
Omo-, pertaining to the shoulder.
Omphalo-, pertaining to the navel.
Operculum, a covering.
Ophryon, the eyebrow.
Ophthalmic, pertaining to the eye.
Opisthion, hinder or rear.
Opisthotic, behind the ear.
Optic, pertaining to sight.
Ora, a border or margin.
Orthognathous, pertaining to a straight or upright jaw.
Os, oris, a mouth.
Os, ossis, a bone.
Osteoblast, bone-germ.
Osteoclast, bone-destroyer.
Osteogenetic, bone-begetting.
Ostium, a door, entrance, or exit.
Otic, pertaining to the ear.
Otoconia, ear-dust.
Otoliths, ear-stones.
Ovary, egg-former.
Oxyntic, producing acid.

Palātum, the palate.
Pallium, a covering.
Palmar, pertaining to the palm.
Palmatæ, marked with the palm.
Palpebra, an eyelid.
Pampiniform, tendril-like.
Pancreas, literally, all flesh.
Para-, near, by the side of.
Paradidymis, near the testis.
Parametrium, near the womb.
Parietal, pertaining to a wall.
Paroöphoron, near the egg-bearing organ.
Parōtid, near the ear.
Patella, a small dish ; a plate.
Patheticus, affecting.
Pecten, the os pubis.
Pectinātus, pertaining to a comb
Pectiniform, comb-like.
Pectineal or **Pectinēus,** pubic.
Pectoralis, pertaining to the breast.
Pelvis, a basin.
Penis, a tail.
Peri-, around, about, or near.
Pericardium, around the heart.
Perineum, from a Greek verb meaning ' I dwell, or am situated, around.'
Periosteum, around a bone.

Periotic, around the ear.
Peritoneum, from a Greek verb meaning 'I stretch around.'
Peronēal or **Peronēus,** pertaining to a buckle, clasp, or brace.
Petrous, rocky.
Phalanx, a rank of soldiers.
Pharynx, the throat.
Phenozygous, having visible arches.
Philtrum, a love charm or potion.
Phrenic, pertaining to the diaphragm.
Pinēal, belonging to, or like, a pine-nut or pine-cone.
Pinna, a kind of shell-fish; a feather or wing.
Pisiform, like a pea.
Pituitary, pertaining to phlegm or mucus.
Placenta, a flat cake.
Plagiocephalous, pertaining to an oblique or twisted head.
Planta, the sole of the foot.
Plantar, pertaining to the sole of the foot.
Platycnēmism, broadness of leg.
Platyrhine, pertaining to a broad nose.
Platysma, a broad sheet.
Pleura, a side, or a rib.
Plexus, a twining or network.
Plica, a fold.
Pneumogastric, pertaining to the breathing organs and stomach.
Pocularis, pertaining to a cup.
Pollex, the thumb.
Pons, a bridge.
Poplitēal or **Poplitēus,** pertaining to the ham.
Porta, a gate.
Portal, pertaining to a gate.
Postaxial, distal or caudal.
Posticus, posterior.
Præputium, the prepuce.
Preaxial, proximal or cephalic.
Proctodæum, the threshold of the anus.
Prognathous, pertaining to a projecting lower jaw.
Proligerus, bearing offspring; germinating.
Pro-nephros, fore-kidney.
Pro-otic, before the ear.
Prosencephalon, the fore-brain.
Prostate, standing before; or, more probably, pertaining to a porch or vestibule.
Psalterium, a psaltery or instrument of the lute kind.
Psoas, the loin.
Pterion, a wing.
Pterotic, pertaining to a wing.
Pterygoid, wing-like.
Pubes, the hair which appears on the external genital organs at the age of puberty.
Pubic, pertaining to the os pubis.
Pudendal, pertaining to the pudendum.
Pudendum, 'of which one ought to be ashamed.'
Pudic, modest or chaste.
Pulmo, a lung.
Pulmonary, belonging to the lungs.
Pulvinar, a couch or cushion.
Putāmen, that which is pruned off; chippings.
Pylōrus, literally, a gate-keeper.
Pyriformis, pear-shaped.

Quadrātus, square.
Quadriceps, having four heads.
Quadrigeminus, fourfold, four.

Racemose, pertaining to a cluster of grapes; full of clusters; clustering.
Radius, a staff or rod; the spoke of a wheel.
Ramus, a branch.
Ranine, pertaining to a frog.
Raphé, a seam.

Receptaculum, a receptacle.
Rectus, straight.
Recurrent, running back.
Refractory, breaking up.
Ren, a kidney.
Renal, pertaining to a kidney.
Restiform, like a rope or cord.
Rete, a net.
Retina, from *rete,* a net.
Retrahens, drawing back.
Revehens, carrying back.
Rhinencephalon, the 'nose' or olfactory brain.
Rhinion, a nose.
Rhombencephalon, the rhomb-brain (hind-brain).
Rima, a cleft or chink.
Risorius, laughing.
Rostrum, a beak.
Rotula, a little wheel.
Rugæ, wrinkles.

Sacrum, sacred.
Sagittal, pertaining to an arrow ; antero-posterior.
Salpinx, a trumpet or tube.
Salvatella, saving, or making well.
Saphēnous, manifest.
Sartorius, pertaining to a tailor.
Scala, a ladder, flight of steps, or staircase.
Scalēnus, of unequal sides.
Scansorius, of, or for, climbing.
Scaphocephalous, pertaining to a head like a boat.
Scaphoid, like a boat.
Scapula, a spade ; probably from a Greek verb meaning 'I dig.'
Schindyiesis, a splitting or cleavage.
Sciatic (identical with **Ischiatic**), pertaining to the hip.
Sclera, hard.
Sclerotic, hard.
Scrobiculus, a little ditch or trench.
Scrotum, a skin-bag or -pouch ; a hide.
Sebaceous, pertaining to tallow, suet, or grease.
Sella, a seat ; a saddle.
Seminalis, pertaining to semen.
Septum, a fence or barrier.
Serotinus, that comes or happens late.
Serrātus, saw-shaped.
Sesamoid, like sesamé (a kind of grain).
Sigmoid, like the Greek letter Σ (sigma).
Sinus, a cavity or hollow.
Smegma, a cleanser.
Solar, relating to the sun.
Soleus, a sole or sandal ; a sole-fish.
Sperma, seed or semen.
Spermatic, pertaining to semen.
Spermatoblast, a seminal bud.
Spermatozoa (plural), seminal animals.
Sphenoid, wedge-like.
Sphenotic, pertaining to the sphenoid bone and ear-capsule.
Sphincter, binding or closing tight.
Splanchnic, pertaining to viscera.
Splenium, a bandage or compress.
Splenius, pertaining to a bandage.
Squamous, scaly.
Stapedius, pertaining to a stirrup.
Stapes, a stirrup.
Stellātum, starry.
Stephanion, a crown or wreath.
Sternebra, a segment of the sternum.
Sternum, the breast or chest.
Stomata, mouths or pores.
Stomatodæum or **Stomodæum,** the threshold of the mouth.
Styloid, pen-like.
Subflava, somewhat yellow.
Sulcus, a furrow.
Sural, pertaining to the calf of the leg.
Sustentaculum, a prop or support.
Suture, a sewing together, a seam.

Symphysis, growth together.
Syn-, with; together with, (union or harmony may be implied).
Synarthrosis, literally, a 'together with' (direct) joint.
Synchondrosis, 'with cartilage.'
Syndesmosis, 'with a band' or 'ligament.'
Synovia, resemblance to the white of an egg.

Tænia, a band or ribbon.
Talus, a die (pl. dice); the ankle-bone.
Tapētum, a carpet or coverlet.
Tarsus, a broad flat surface; the instep.
Tectorius, pertaining to a cover.
Tegmen, a covering.
Tegmentum, a covering.
Tela, a web.
Telencephalon, the end-brain.
Temporal, pertaining to time.
Tendon, from *tendo,* 'I stretch.'
Tentorium, a tent.
Tenuis, slender, small.
Teres, rounded.
Testis, a witness.
Thalamencephalon, the bed-chamber-brain, or inter-brain.
Thalamus, a bed-chamber, situated between two other rooms; a marriage-bed.
Theca, a cover, case, or sheath.
Thenar, pertaining to the palm.
Thorax, the breast or chest; a breast-plate.
Thymus, thyme.
Thyroid, like a shield.
Tibia, a pipe or flute; the shin-bone.
Tinca, a small fish, perhaps the tench.
Torcular, a wine-press (twisting is implied).
Torus, a protuberance.
Trabecula, a little beam.
Trachea ('rough'), the wind-pipe.
Trachēlo-, belonging to the neck.
Tragus, a goat.
Trapezium, a table; a four-sided figure, no two sides of which are parallel to one another.
Trefoil, having three leaves.
Triceps, having three heads.
Trigeminus, threefold, triple.
Trigonocephalus, a triangular head.
Trigōnum, a triangle; triangular.
Triquetrum, three-cornered; triangular.
Triticĕa, wheaten.
Trochanter, from a Greek verb meaning 'I roll, turn, or revolve.'
Trochlea, the wheel of a pulley.
Trochlear, pulley-shaped.
Trochlearthrosis, a pulley-joint.
Trochoides, wheel-like.
Tuba, a trumpet.
Tubarius, pertaining to a trumpet.
Tubercle, a small swelling.
Tuberosity, an exaggerated tubercle.
Turbinate, whirled or coiled; like a top.
Turbo, a whirl or coil; a top.
Turcica, Turkish.
Tympanum, a drum.

Ulna, the elbow.
Umbilicus, the navel.
Umbo, a boss or knob.
Unciform, hook-like.
Uncinate, furnished with a hook.
Ungual, relating to a nail.
Unguis, a nail.
Unicornis, one-horned.
Urăchus, urine-holder.
Urĕter, from a Greek verb meaning 'I pass urine.'
Urethra, the canal by which urine is passed.
Uriniferous, urine-carrying.
Uterus, the womb or matrix.

Utricle, a little womb or matrix.
Uvĕa, from *uva*, a bunch of grapes ; a cluster.
Uvula, a small bunch of grapes.

Vagina, a scabbard or sheath.
Vagus, strolling about, wandering, vagrant.
Vallecula, a little valley.
Vallum, a rampart.
Vas (pl. vasa), a vessel.
Velum, a curtain or veil.
Veneris, ' of Venus.'
Ventral, pertaining to the belly.
Ventricle or **Ventriculus,** a little belly.
Vermiform, like a worm.
Vertebra, from *verto*, ' I turn.'
Vertex, the top or crown of the head.
Veru, a dart, javelin, or spear.
Vesica, the urinary bladder.
Vesical, pertaining to the urinary bladder.
Vespertilio, a bat.
Vestigial, pertaining to a trace.
Vestigium, a trace or vestige.
Vibrissa, a stiff hair of the nostril.
Villus, shaggy hair; a tuft of hair.
Vinculum, a band or bond.
Vitelline, pertaining to the yolk of an egg.
Vitellus, the yolk of an egg.
Vitreous, like glass, glassy.
Vola, the palm of the hand.
Volar, pertaining to the palm : palmar.
Vomer, a ploughshare.
Vorticosæ, full of whirlpools. eddying, coiled.
Vulva, a wrapper or covering.

Xiphoid, like a sword.

Zygōma, a yoke.

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